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Luther et al.

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(54) **CONFIGURABLE MODULAR POWER CONTROL SYSTEM**

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(72) Inventors: **Robert Luther**, Chester, CT (US); **Joshua Liposky**, Shelton, CT (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 188 days.

(21) Appl. No.: **14/057,430**

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Related U.S. Application Data

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(51) **Int. Cl.**

H05K 5/00	(2006.01)
H02B 1/56	(2006.01)
H05K 7/20	(2006.01)
H05K 7/14	(2006.01)
H02M 7/00	(2006.01)
G06F 1/16	(2006.01)

(52) **U.S. Cl.**

CPC ***H02B 1/565*** (2013.01); ***H02M 7/003*** (2013.01); ***H05K 5/00*** (2013.01); ***H05K 7/1432*** (2013.01); ***H05K 7/20*** (2013.01)

(58) **Field of Classification Search**

CPC H05K 7/20; H05K 7/1432; H05K 7/1457; H05K 7/20572; H05K 5/00; H02M 7/003; H02B 1/565; H02B 1/04; G06F 1/16; G06F 1/20

USPC ..... 361/601, 605, 611, 614, 622, 624, 627, 361/641, 644, 631, 657, 728, 730, 87, 93.1, 361/93.9, 103; 363/141, 144; 174/17 R, 174/17 VA, 17 CT, 50, 520, 522, 526; 307/18, 42, 43, 147, 149; 315/112, 315/114, 115, 291, 312; 312/223.1, 236

See application file for complete search history.

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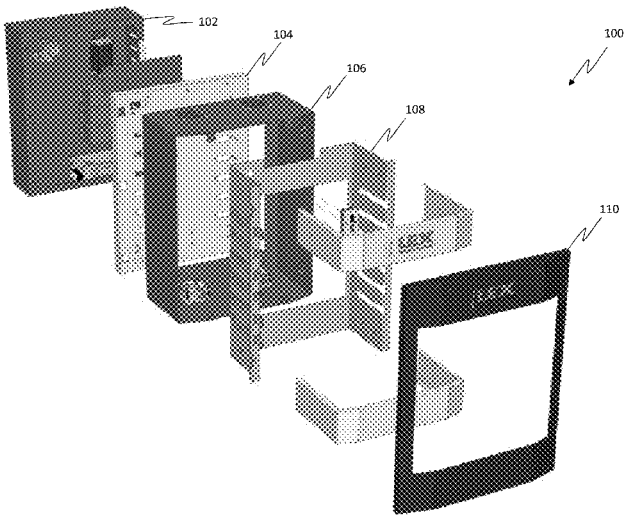
(57) **ABSTRACT**

A modular power control system is provided and includes a base enclosure, wherein the base enclosure and a base enclosure door, wherein the base enclosure defines a base enclosure cavity and the base enclosure door defines a base enclosure door cavity. Additionally, a module enclosure is provided and includes a module enclosure top, a module enclosure bottom, and two module enclosure sides, wherein the module enclose defines a module enclosure cavity and a module enclosure internal support, wherein the module enclosure internal support includes a module enclosure internal support rear and two module enclosure internal support sides having a first module guide channel located on one of the two module enclosure internal support sides and a second module guide channel located on the other of the two module enclosure internal support side.

20 Claims, 24 Drawing Sheets



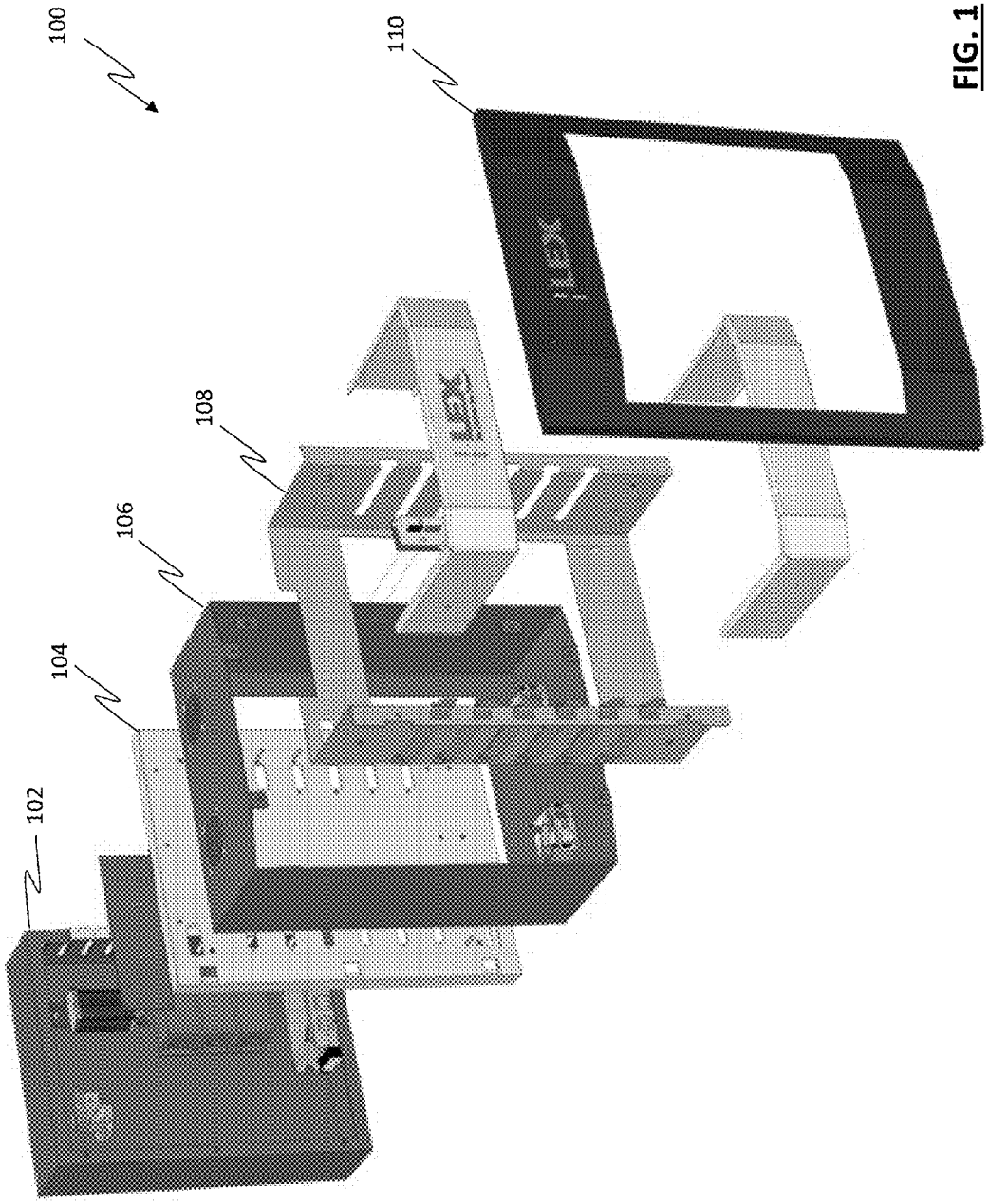


FIG. 1

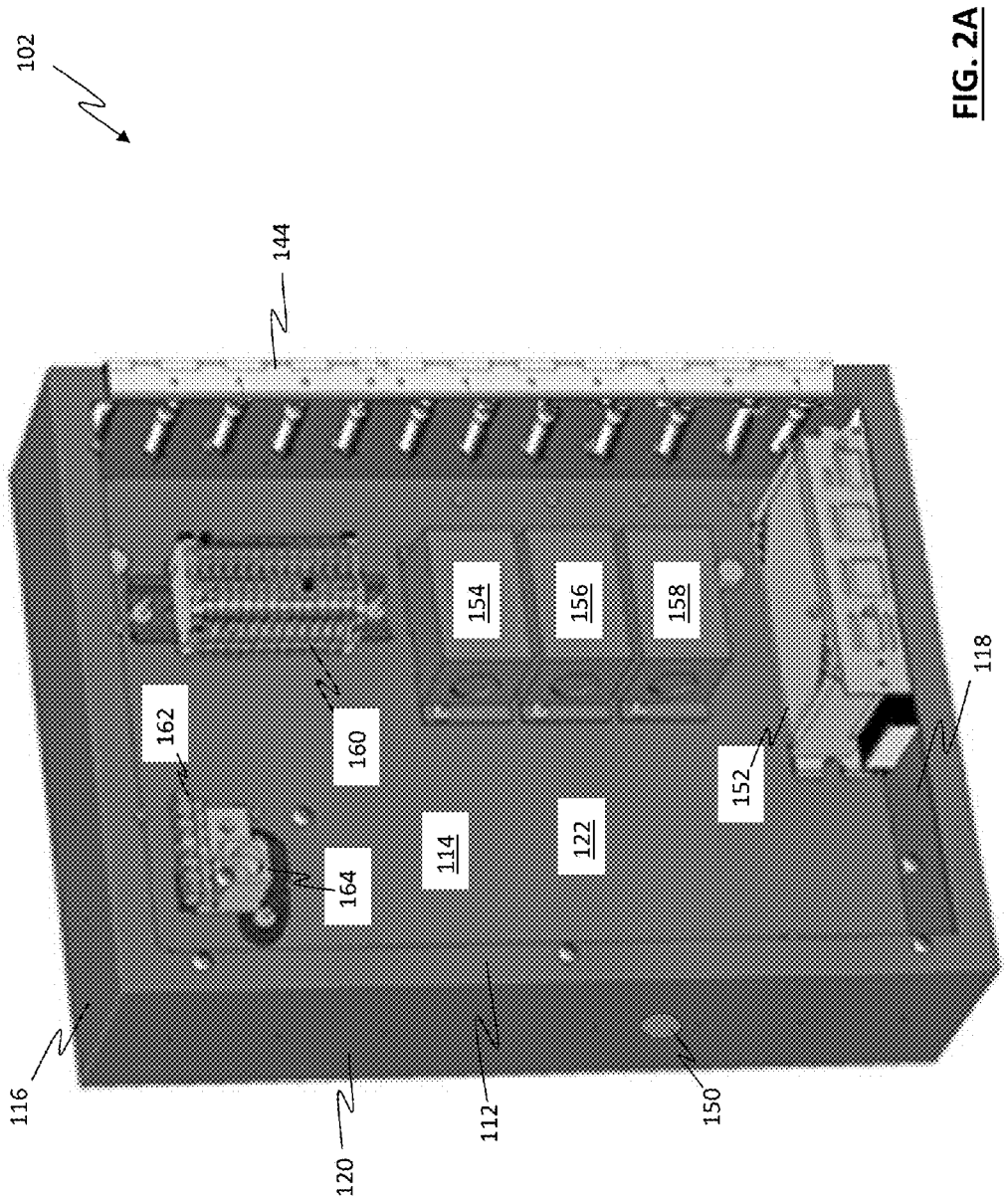


FIG. 2A

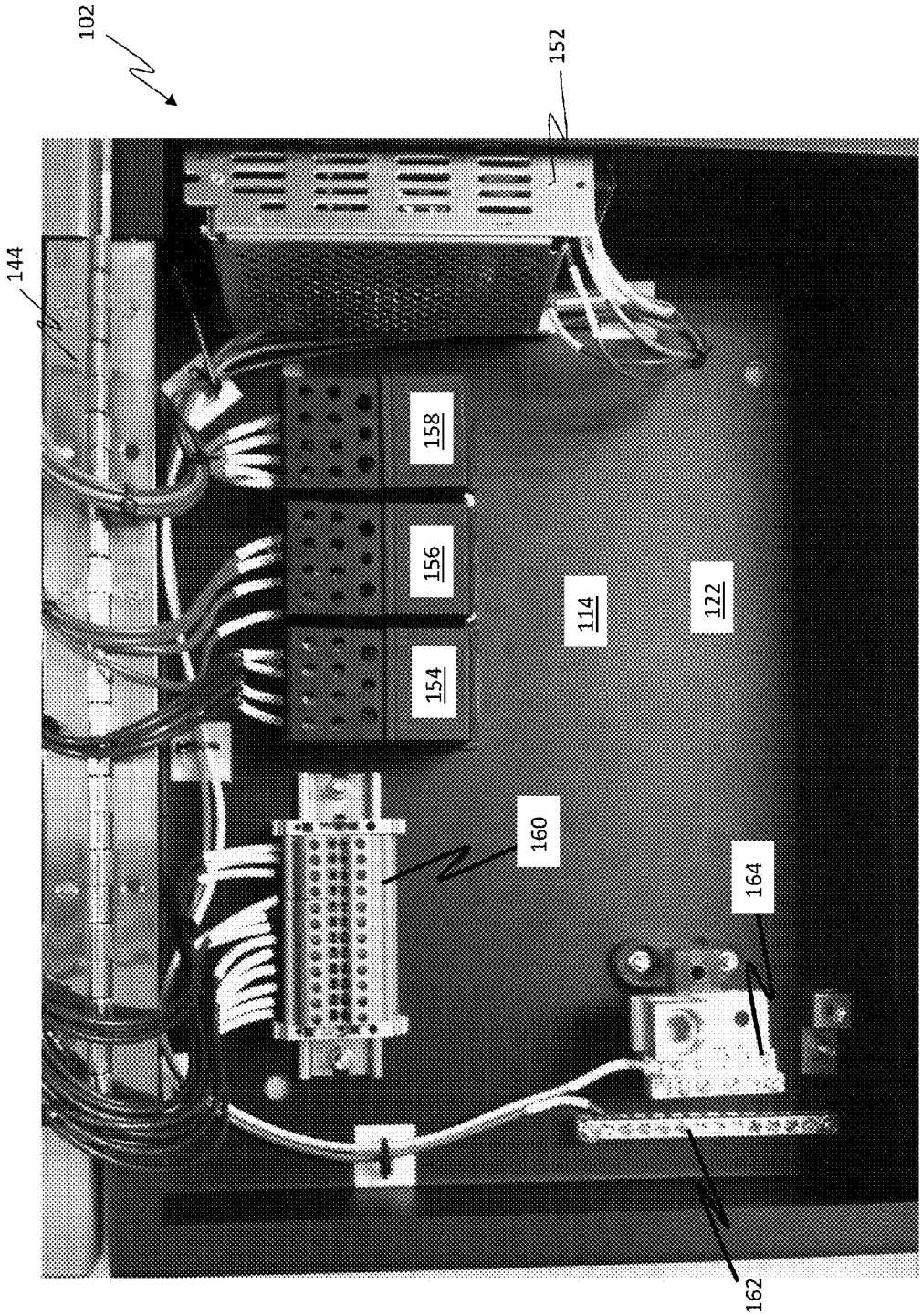
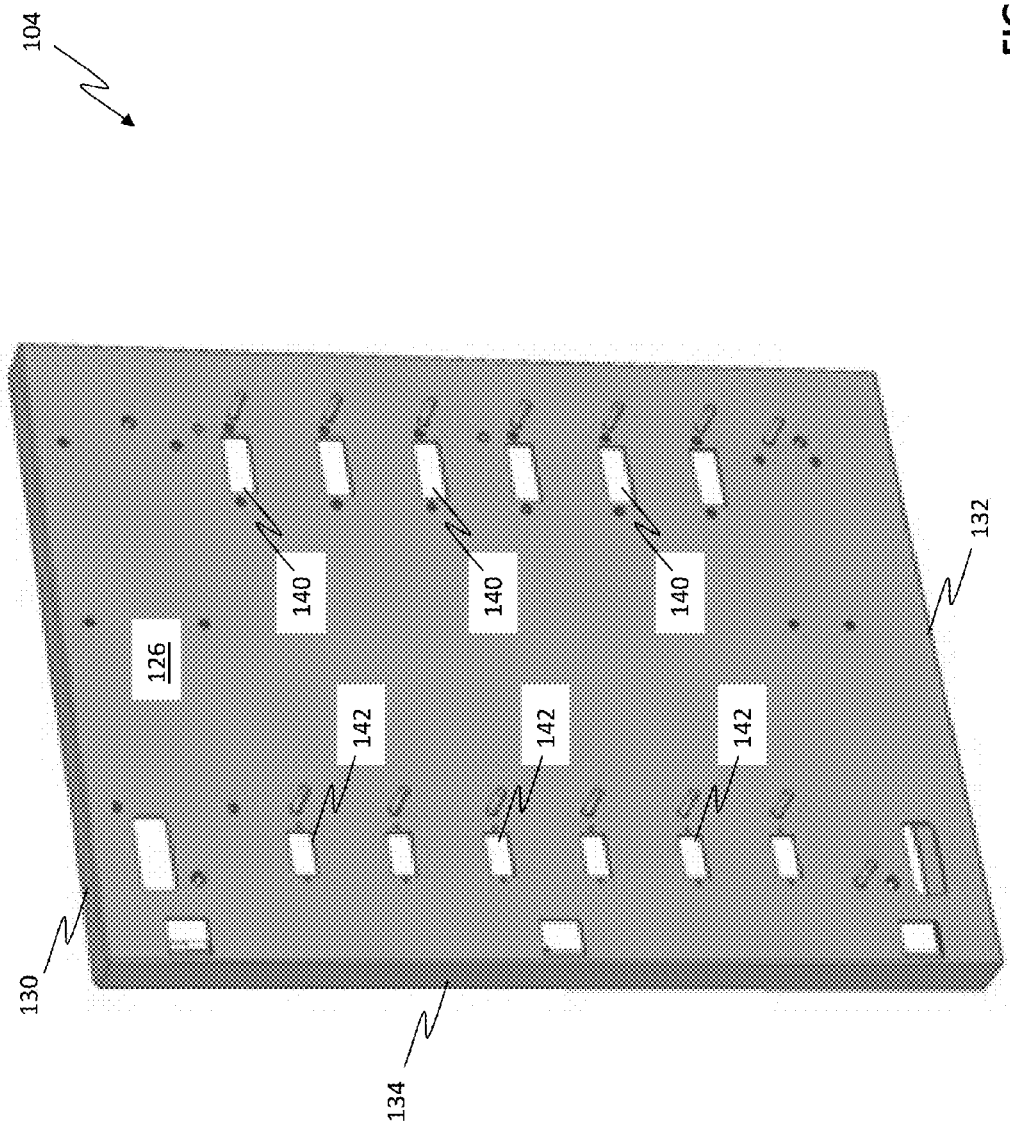


FIG. 2B

FIG. 3A



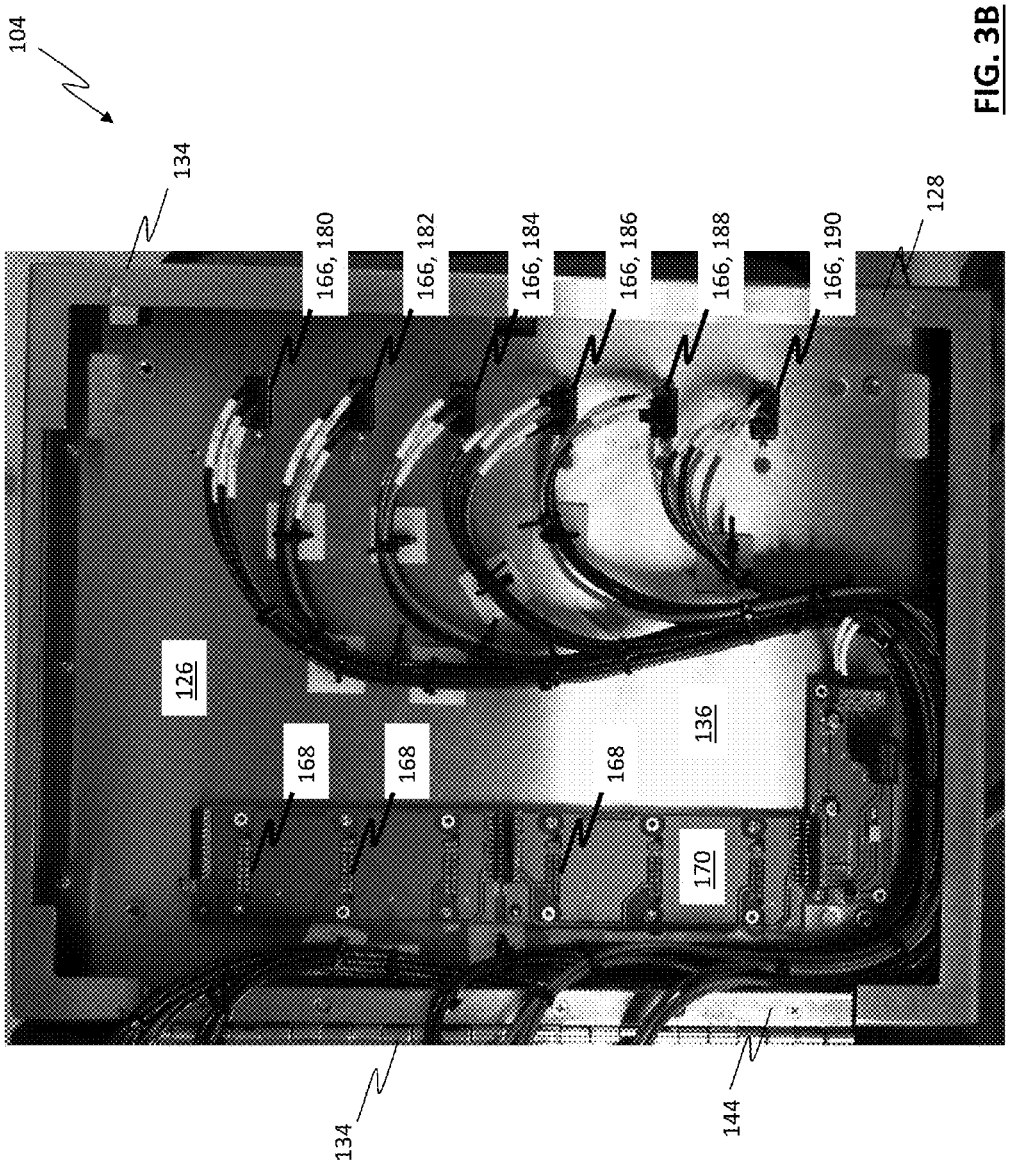

104
134
166, 180
166, 182
166, 184
166, 186
166, 188
166, 190
128
126
168
168
168
136
170
134
144

FIG. 3B

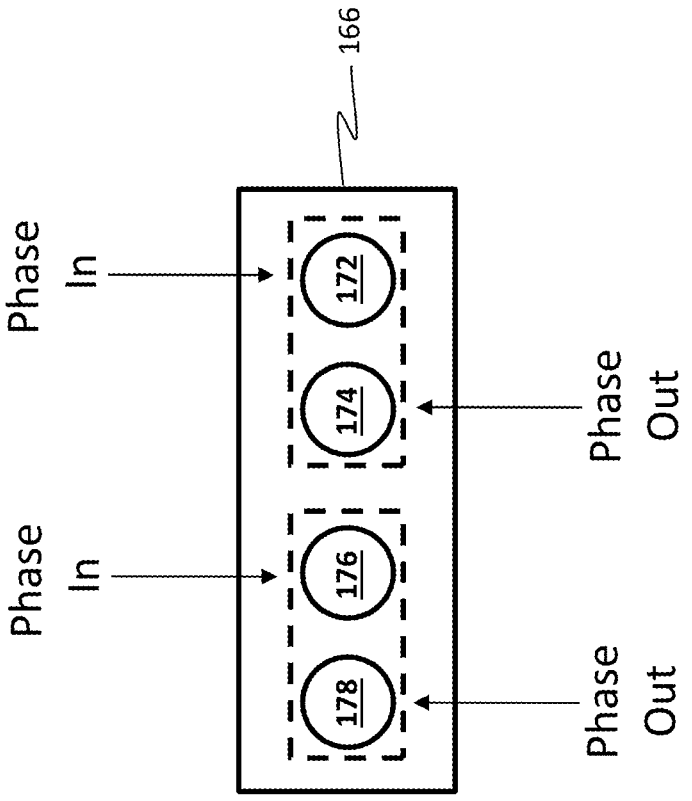
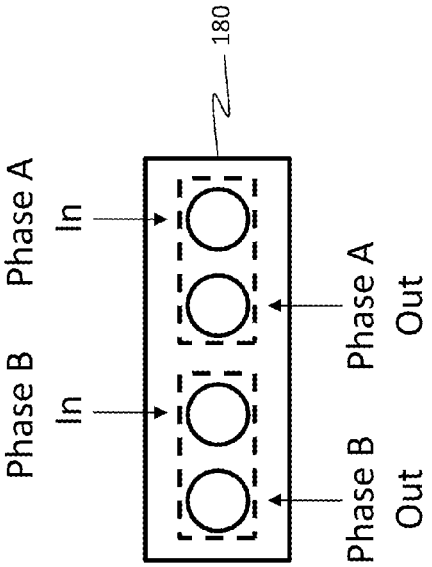


FIG. 4A


180
Phase A
In
Phase B
In
Phase A
Out
Phase B
Out

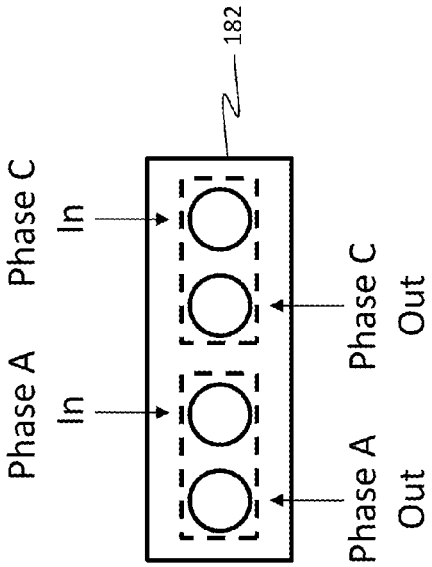
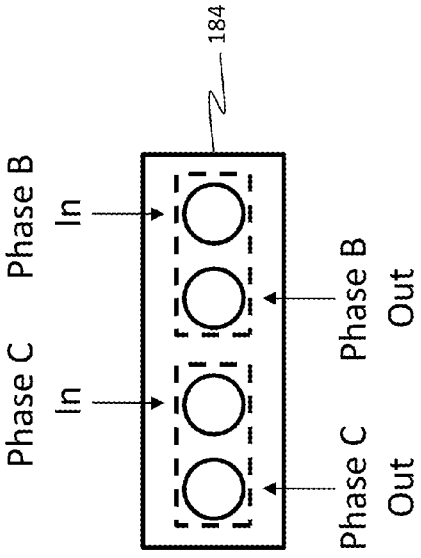

182
Phase C
In
Phase A
In
Phase C
Out
Phase A
Out

FIG. 4B


184
Phase B
In
Phase C
In
Phase B
Out
Phase C
Out

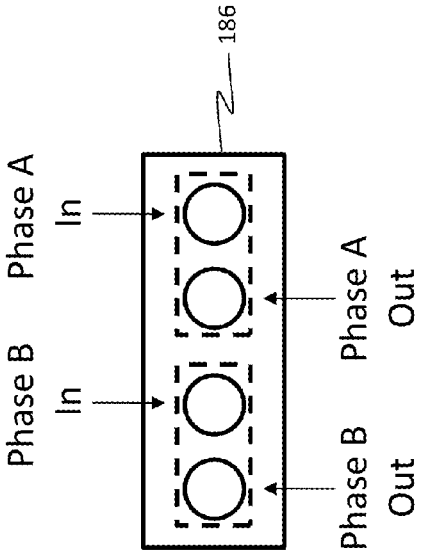
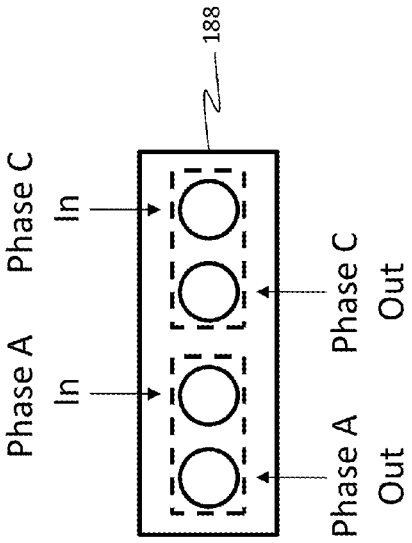

186
Phase A
In
Phase B
In
Phase A
Out
Phase B
Out

FIG. 4C


188
Phase C
In
Phase A
In
Phase C
Out
Phase A
Out

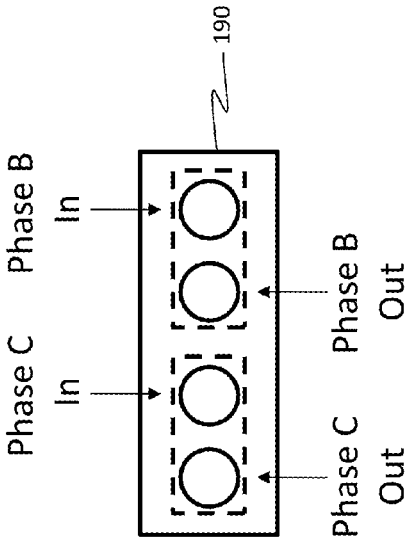

190
Phase B
In
Phase C
In
Phase B
Out
Phase C
Out

FIG. 4D

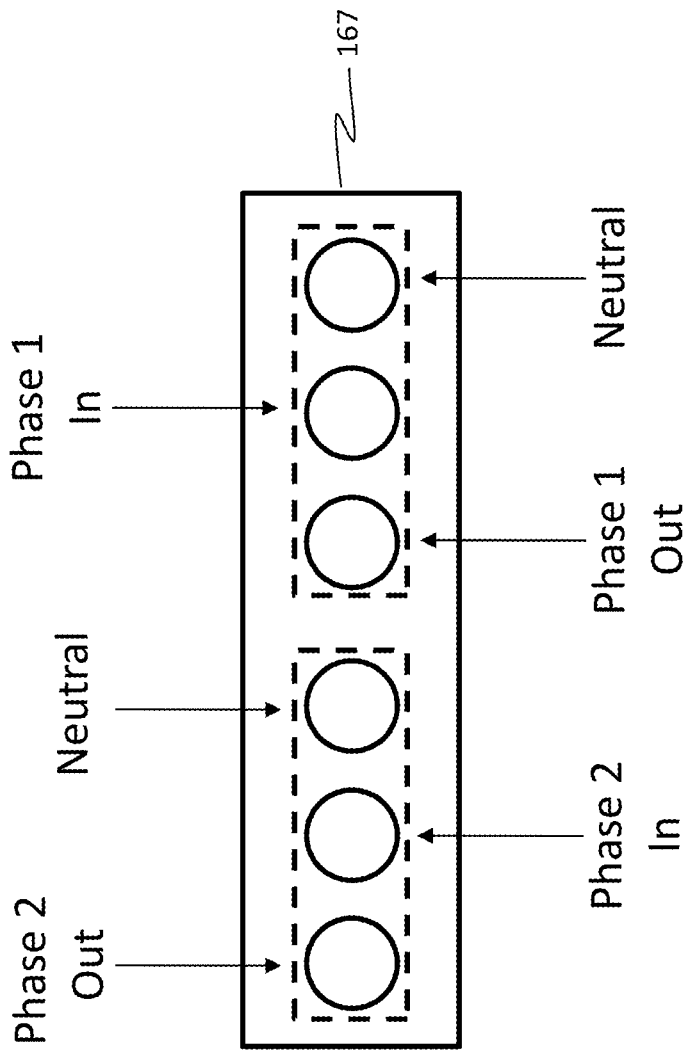

167
Phase 1
In
Neutral
Phase 1
Out
Neutral
Phase 2
In
Phase 2
Out

FIG. 4E

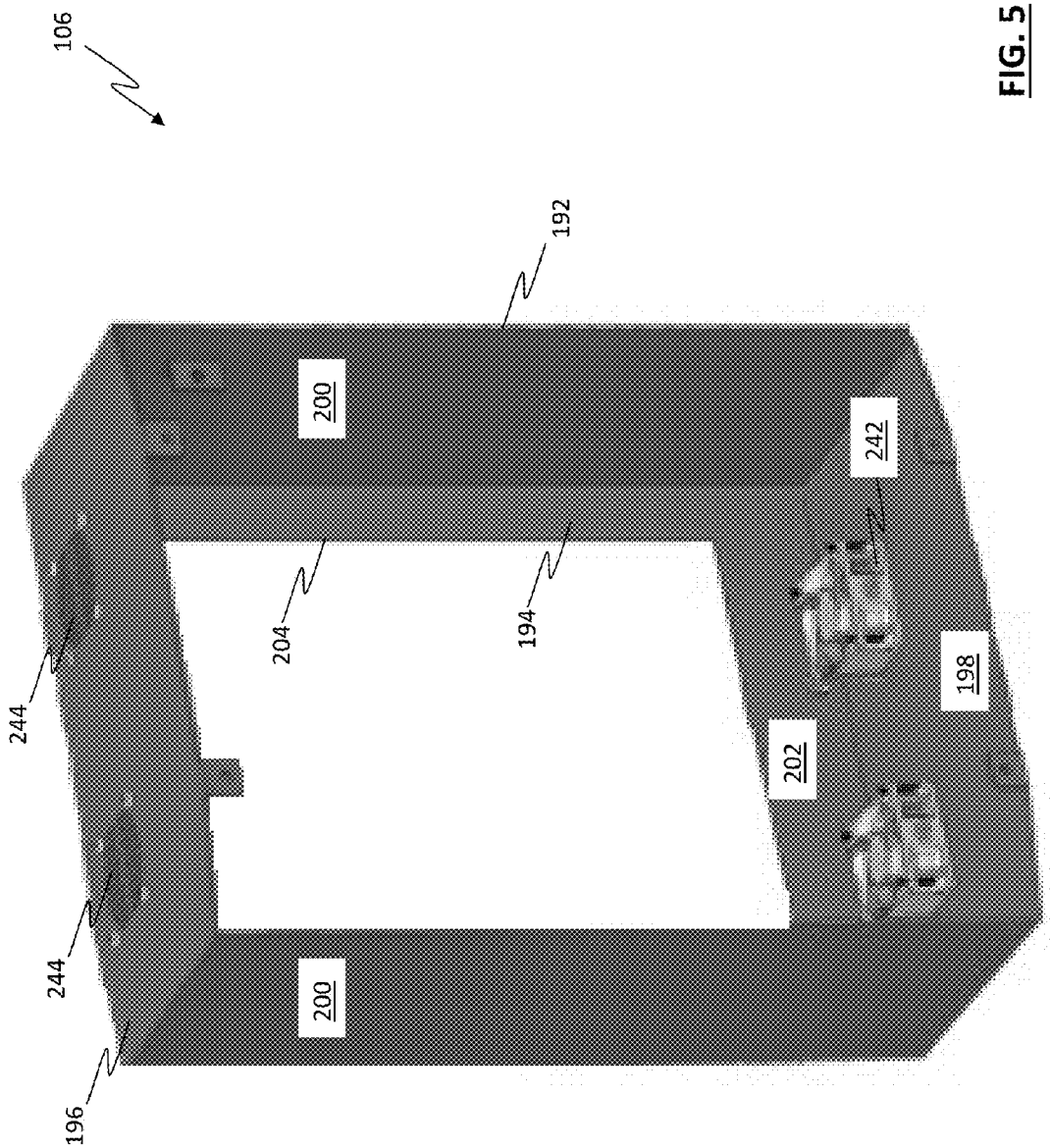


FIG. 5

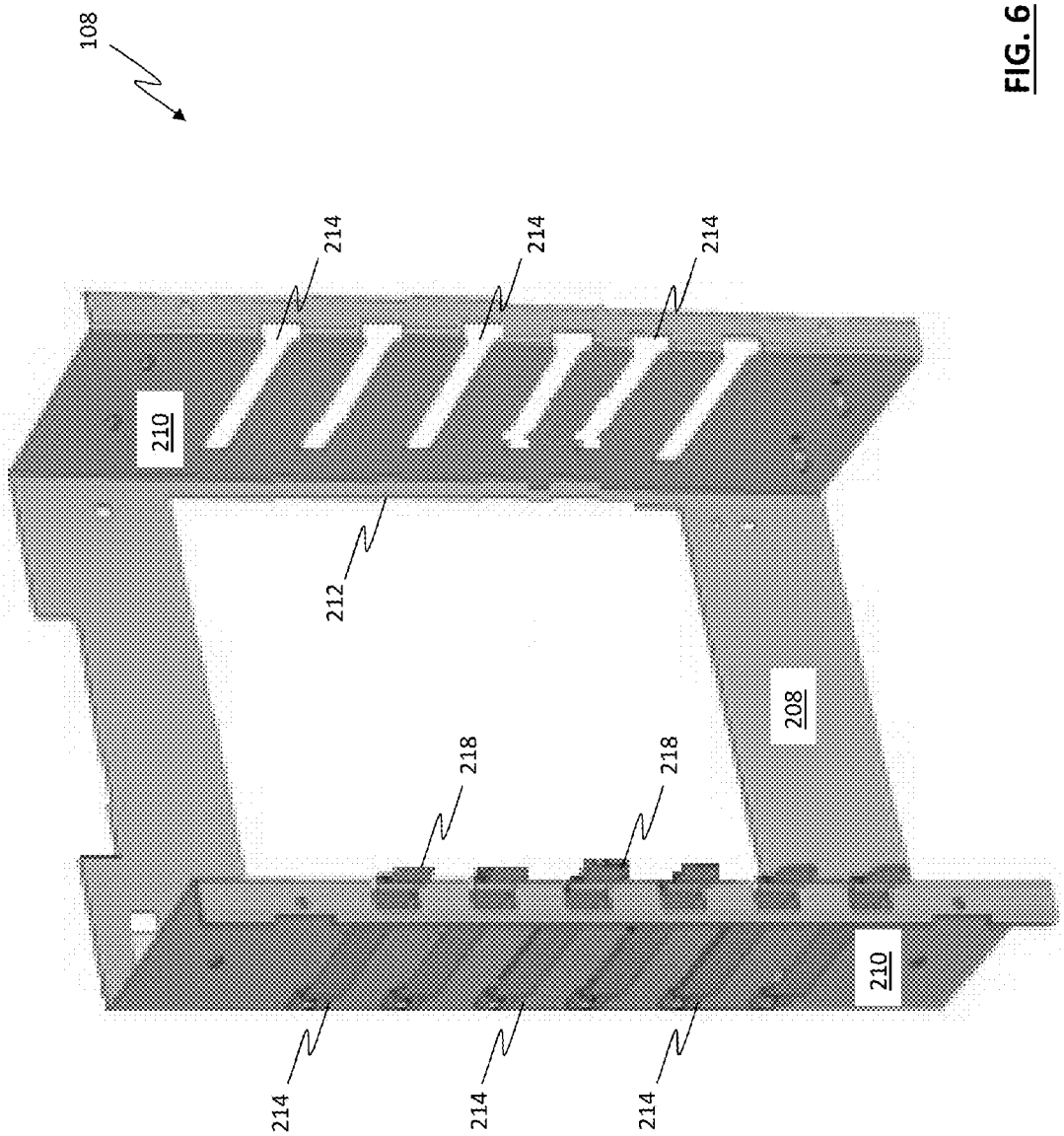


FIG. 6

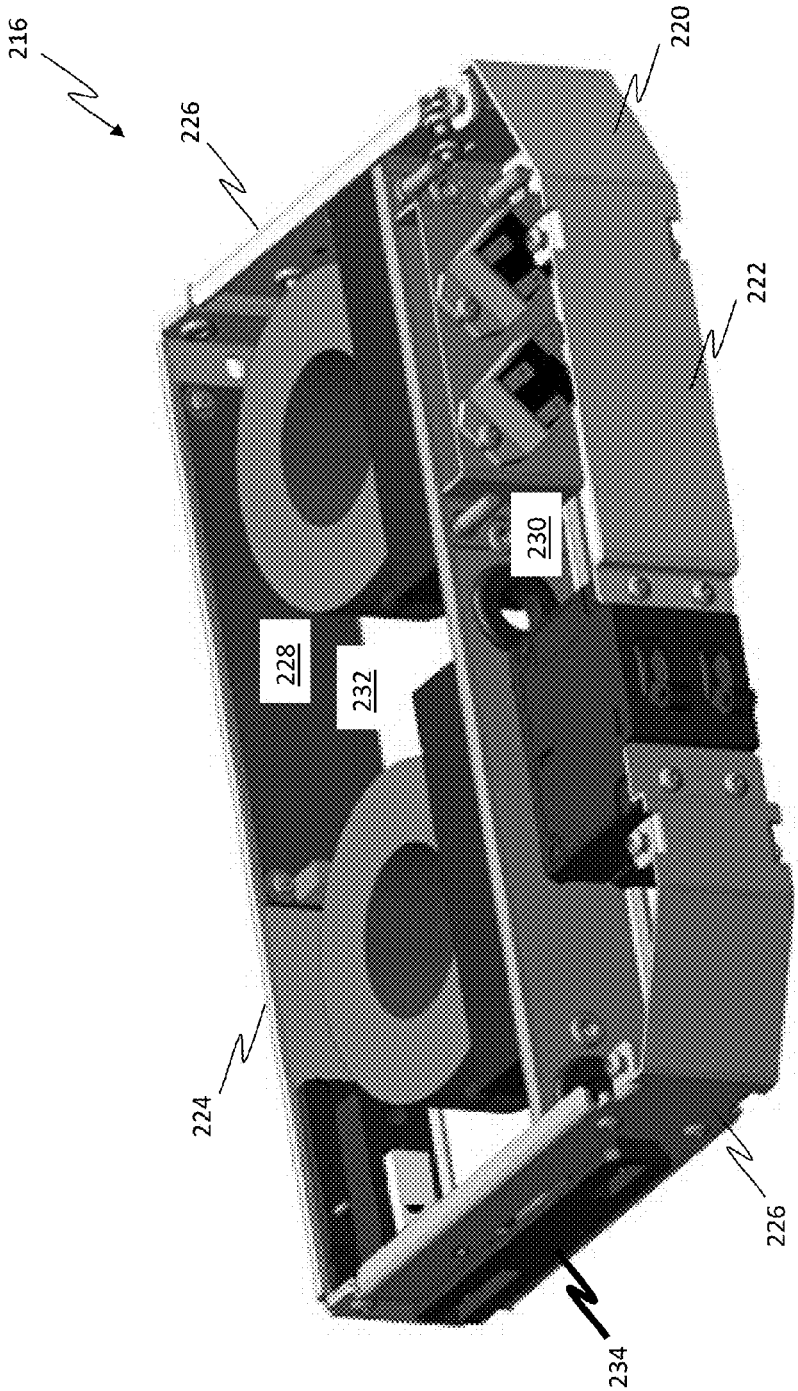


FIG. 7A

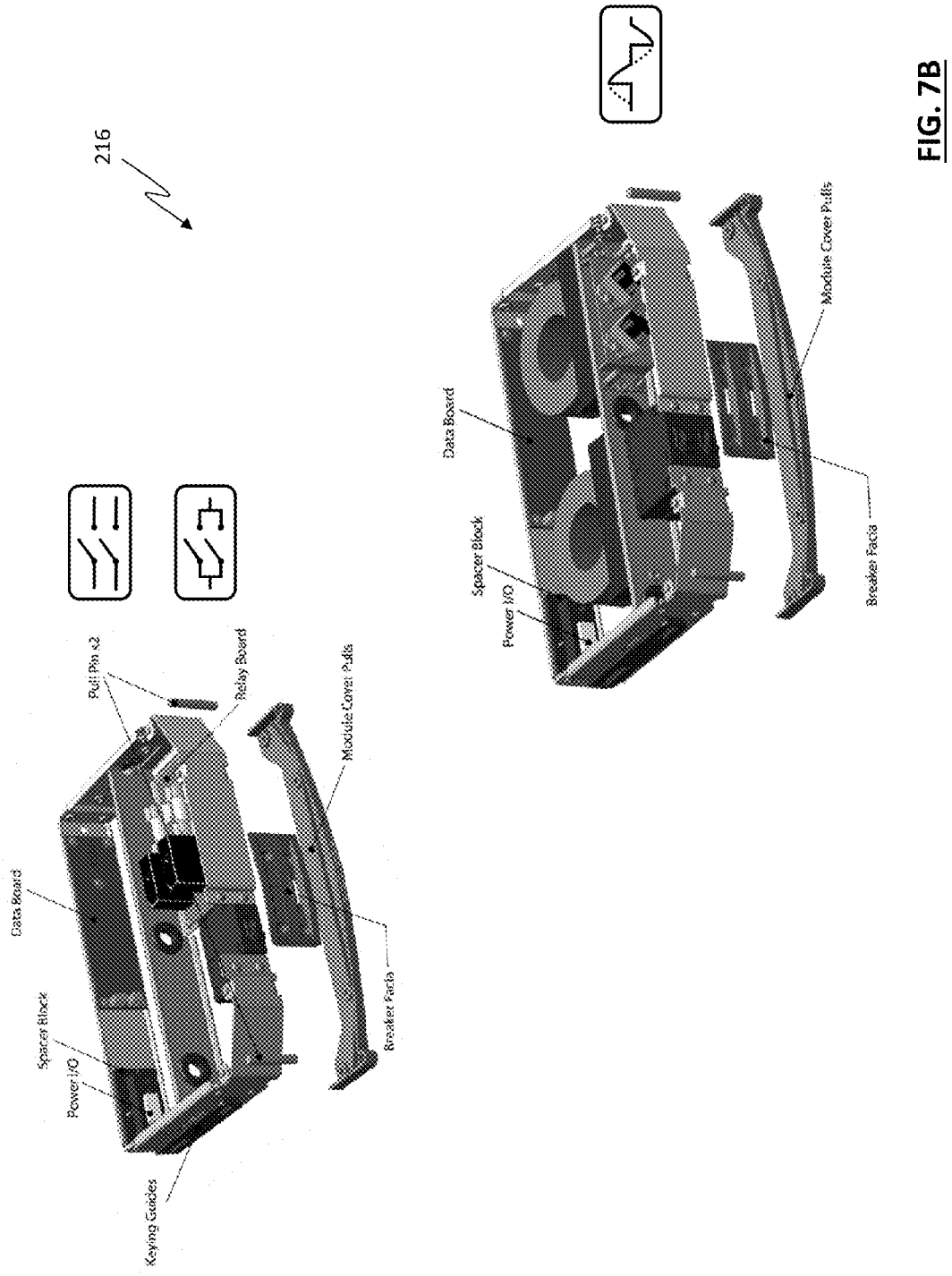

216
Pull Pin x2
Relay Board
Module Cover Pulls
Data Board
Spacer Block
Power I/O
Breaker Facia
Keying Guides
Data Board
Spacer Block
Power I/O
Module Cover Pulls
Breaker Facia

FIG. 7B

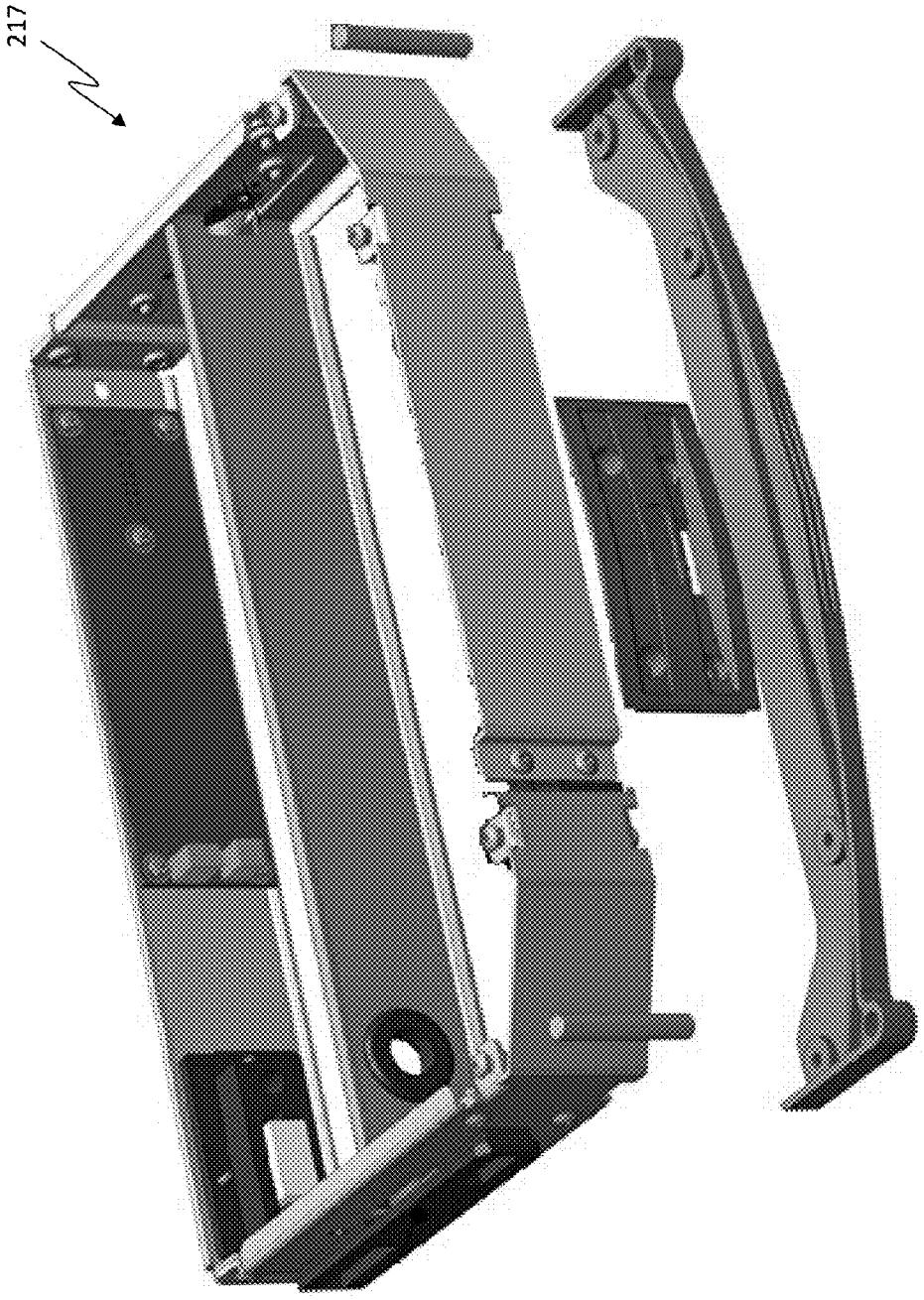


FIG. 7C

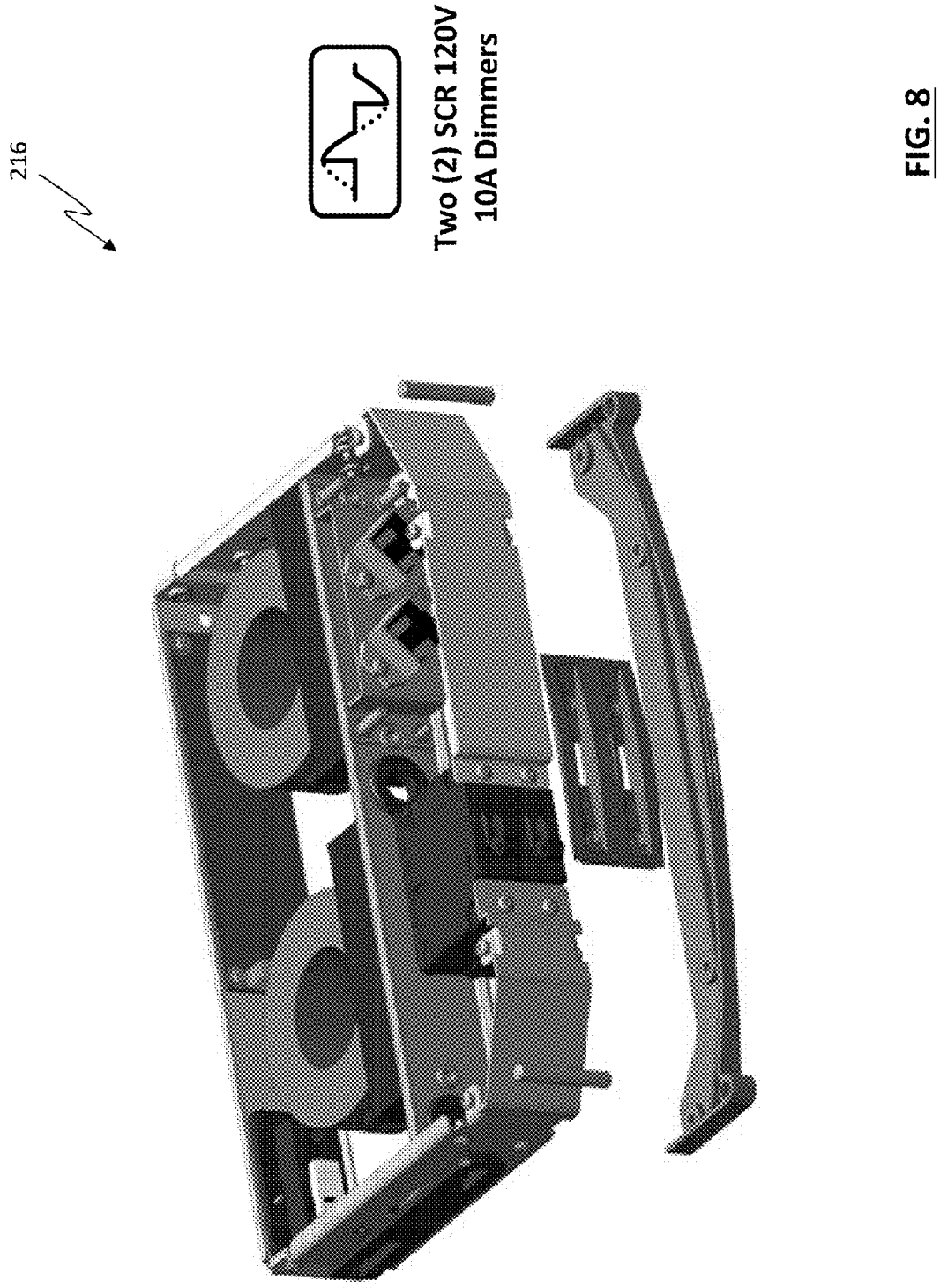


FIG. 8

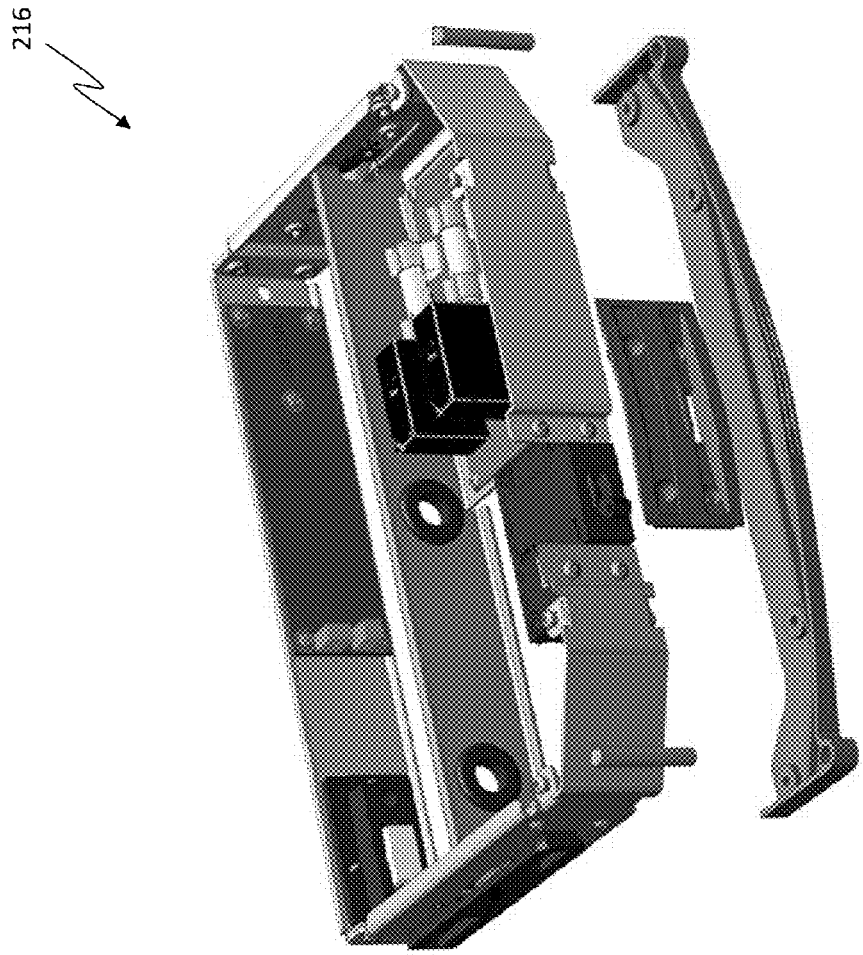

216
Two (2) Single-Pole 20A 120V Relays
One (1) Double-Pole 20A 220V Relay

FIG. 9

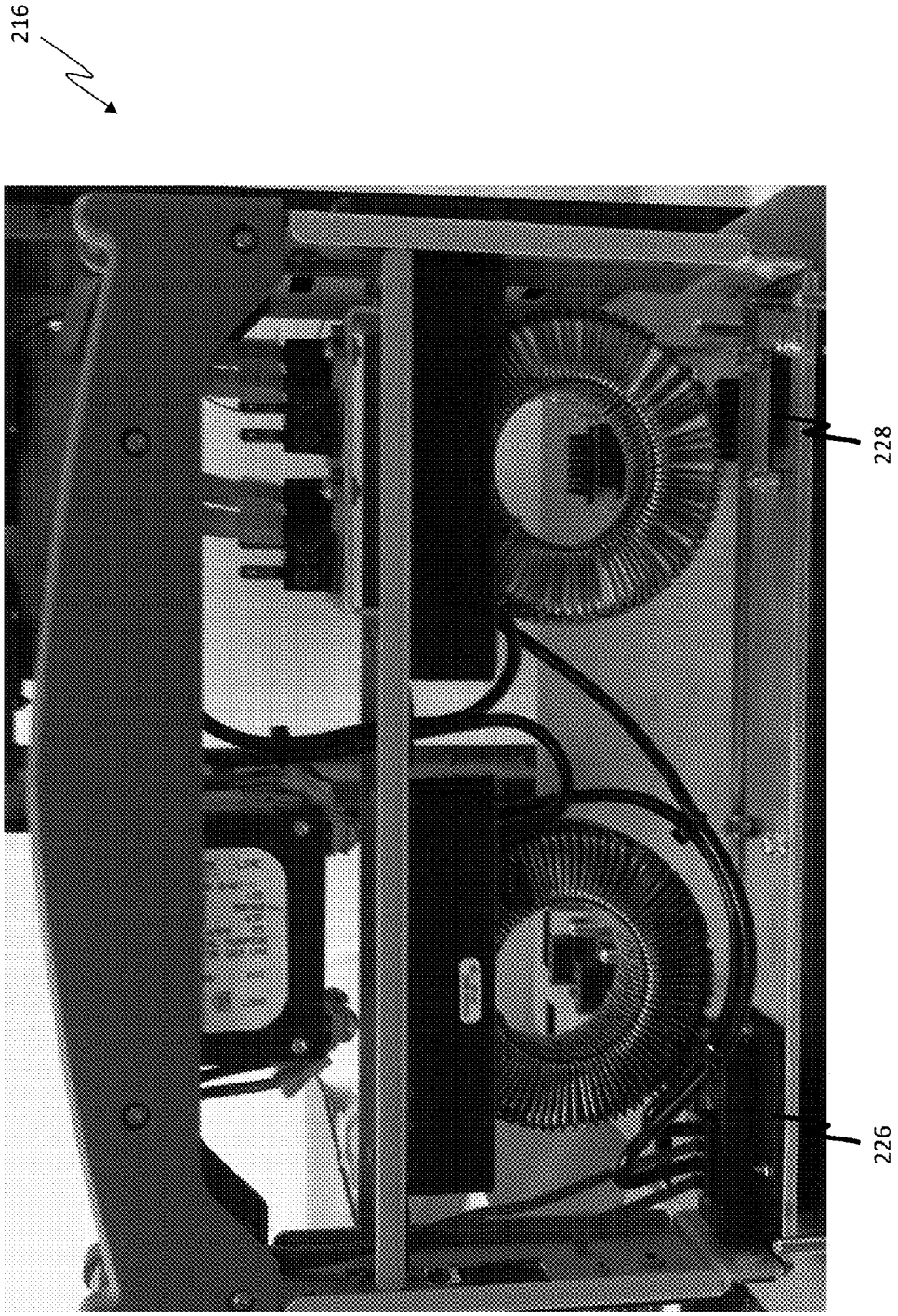


FIG. 10

FIG. 11

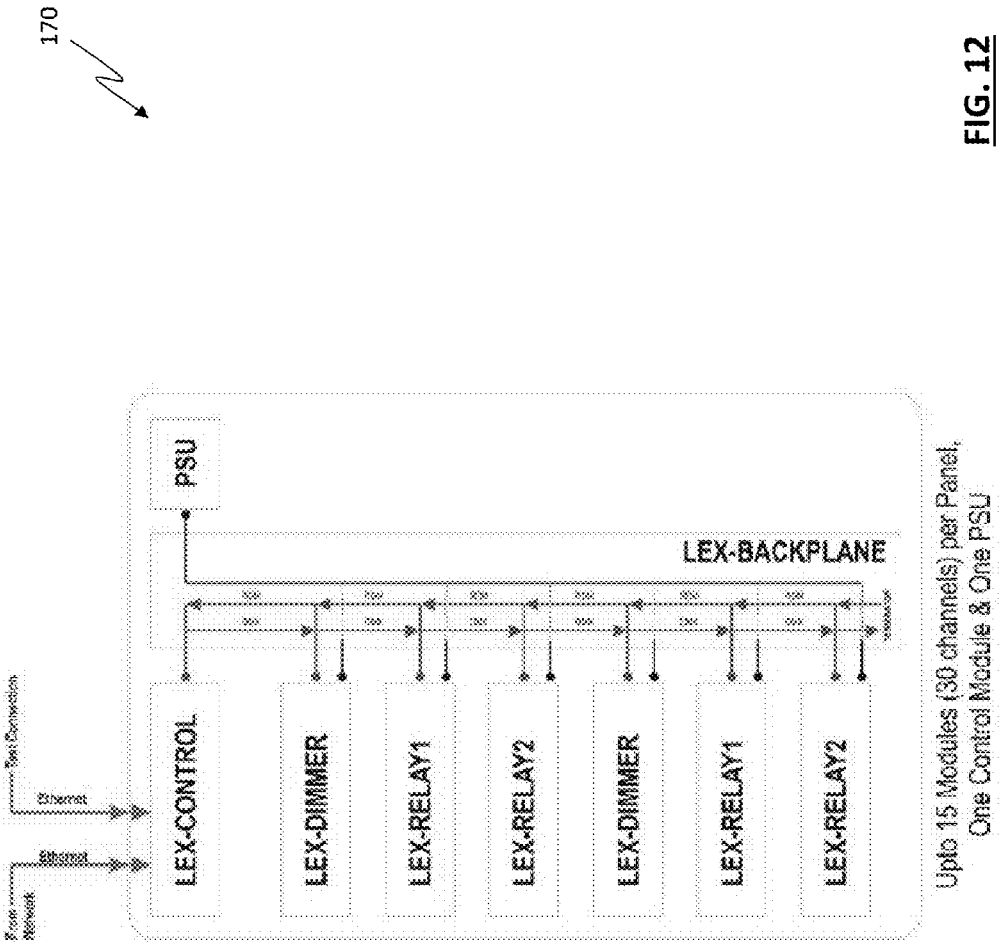

170
PSU
LEX-BACKPLANE
LEX-CONTROL
LEX-DIMMER
LEX-RELAY1
LEX-RELAY2
LEX-DIMMER
LEX-RELAY1
LEX-RELAY2
Upto 15 Modules (30 channels) per Panel,
One Control Module & One PSU

FIG. 12

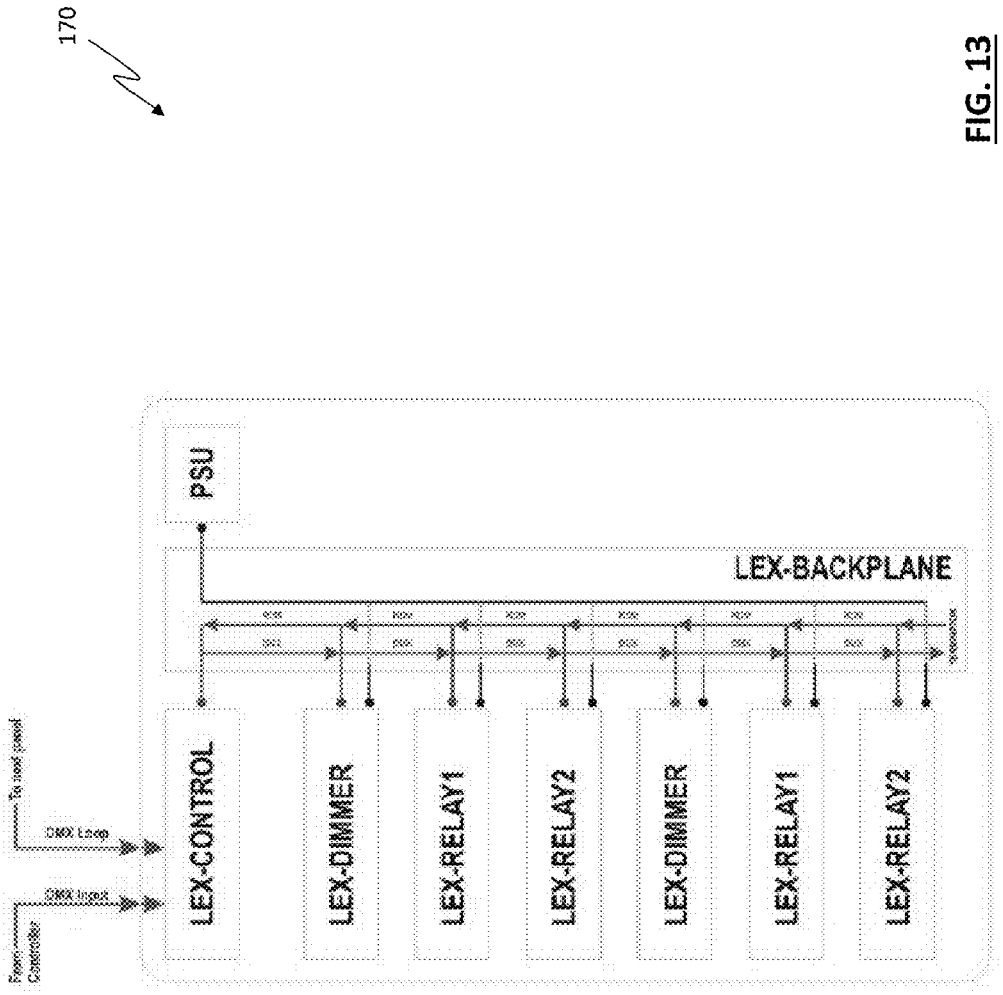

170
PSU
LEX-BACKPLANE
LEX-CONTROL
LEX-DIMMER
LEX-RELAY1
LEX-RELAY2
LEX-DIMMER
LEX-RELAY1
LEX-RELAY2
To next panel
DMX Loop
DMX Input
From Lighting Controller

FIG. 13

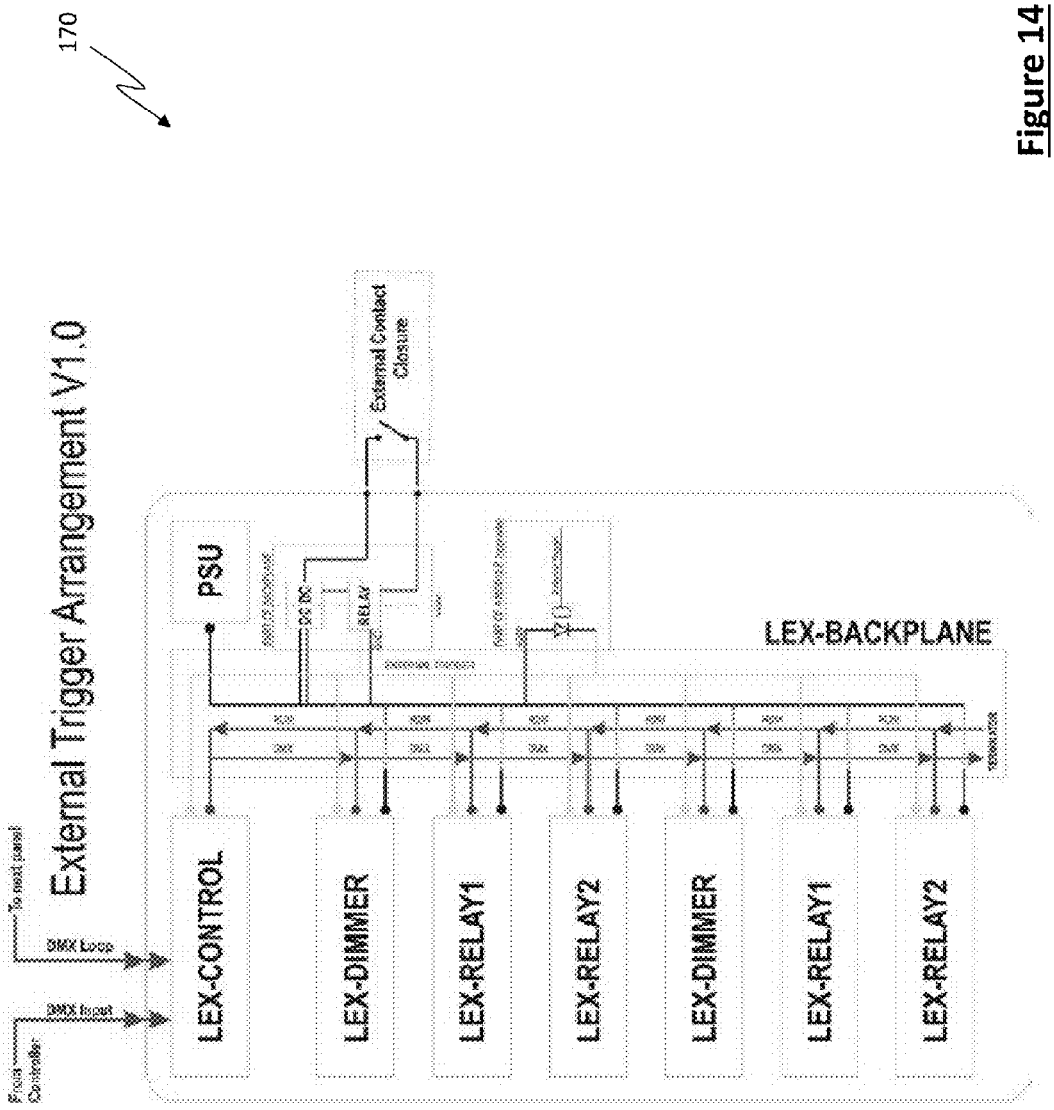

170
External Trigger Arrangement V1.0
PSU
External Contact Closure
LEX-BACKPLANE
LEX-CONTROL
LEX-DIMMER
LEX-RELAY1
LEX-RELAY2
LEX-DIMMER
LEX-RELAY1
LEX-RELAY2

Figure 14

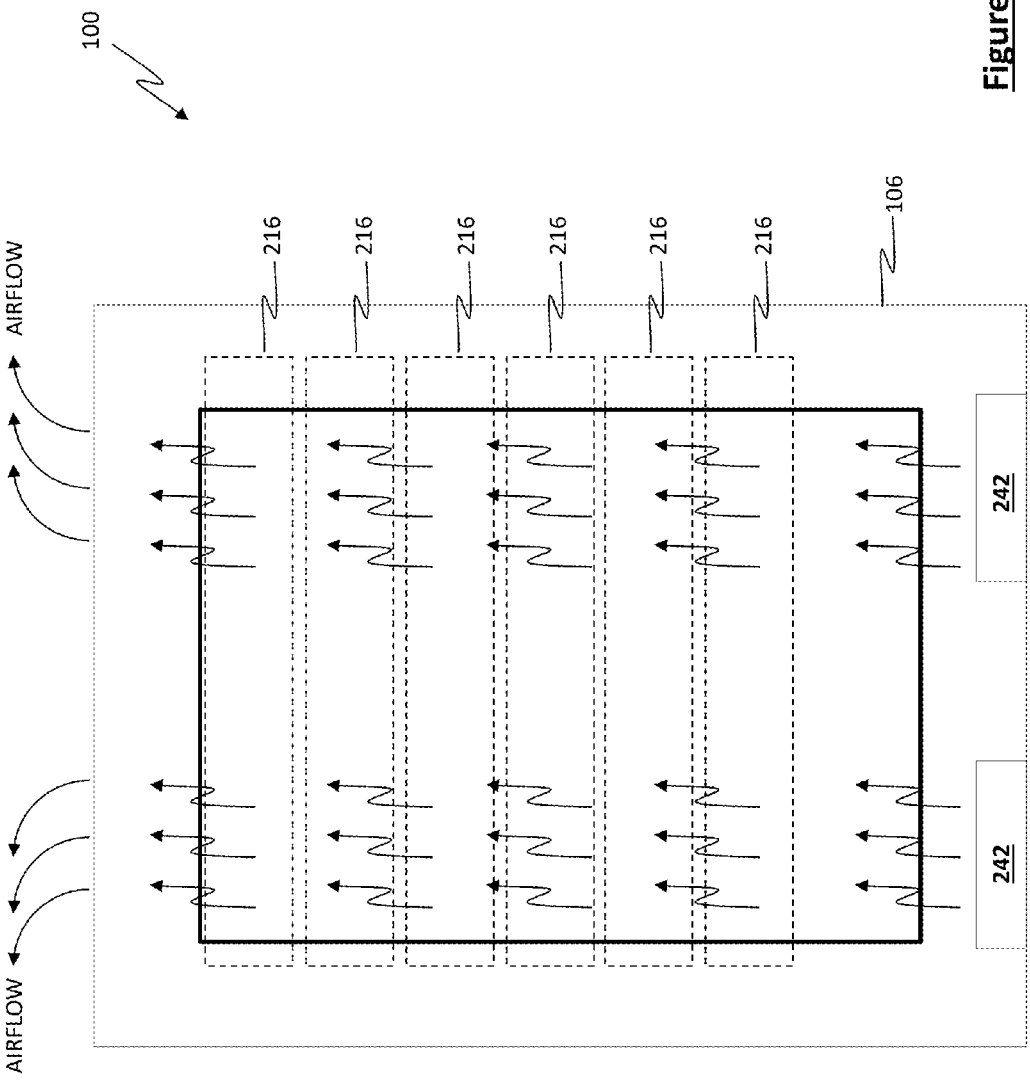


Figure 15

INSTALLATION PANELS				
MODULE CAPACITY	HEIGHT	WIDTH	DEPTH	PANEL CAPACITY
3	11.2"	12.8"	12.2"	40A 3Ø 208Y/120V
6	16.6"	12.8"	12.2"	80A 3Ø 208Y/120V
9	22.0"	12.8"	12.2"	120A 3Ø 208Y/120V
12	27.4"	12.8"	12.2"	160A 3Ø 208Y/120V
15	32.8"	12.8"	12.2"	200A 3Ø 208Y/120V

Figure 16

CONFIGURABLE MODULAR POWER CONTROL SYSTEM

RELATED APPLICATIONS

This application is related to and claims the benefit of the filing date of U.S. Provisional Patent Application Ser. No. 61/715,358, filed Oct. 18, 2012, the contents of which are incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

The present invention relates generally to a system for controlling power and more particularly to a modular power control system that is configurable to accomplish various types of power control operations such as dimmer control and single-pole/double-pole relay requirements.

BACKGROUND OF THE INVENTION

Power control systems that control dimmer and power relay operations lighting and other devices are known in the art and are typically constructed using large enclosures that have exposed bus bars (one bus bar for each electrical phase) and other electrical connections. Moreover, the components used to accomplish the task of controlling dimmer and power relay functions are 'hardwired' into the enclosure and typically require a large amount of wiring which results in a virtual 'rats nest' of wires inside of the enclosure. Furthermore, as these systems deal with large power applications, the components used typically generate large amounts of heat.

Unfortunately however, current designs do little in the way of providing a safe environment for technicians that must work on these systems. The exposed bus bars and electrical connections create a safety hazard for people that have access the internal area of the enclosure. This is undesirable because electrocution and shock can not only occur when the components and bus bars are accidentally touch, but with high power devices such as relays, switches, circuit breakers, etc. if an individual gets to close an electric arc may occur. Accordingly, although a trained technician may have a reduced risk of electric shock, the exposed nature of the components and bus bars makes that risk more prevalent.

Additionally, the current enclosures are not designed to efficiently dissipate the heat generated by the components. Accordingly, the temperature within the enclosure typically rises to a high level and may result in failure of the components. This creates a tempting opportunity to leave the enclosure door open to help dissipate the heat. Unfortunately, this creates a furthermore safety hazard by allowing access into the system enclosure and exposing non-trained personnel to the electrical components within the enclosure.

SUMMARY OF THE INVENTION

A modular power control system is provided and includes a base enclosure having a base enclosure top, a base enclosure bottom, a base enclosure front, a base enclosure rear and two base enclosure sides, wherein the base enclosure defines a base enclosure cavity. The module power control system further includes a base enclosure door having a base enclosure door top, a base enclosure door bottom, a base enclosure door front, a base enclosure door rear and two base enclosure door sides, wherein the base enclosure door defines a base enclosure door cavity. Additionally, that module power control system further includes a module enclosure having a module enclosure top, a module enclosure bottom, a module enclosure rear and two module enclosure sides, wherein the module enclose defines a module enclosure cavity and includes at least one fan on the module enclosure bottom and at least one vent opening in the module enclosure top. The module power control system also includes a module enclosure internal support, wherein the module enclosure internal support includes a module enclosure internal support rear and two module enclosure internal support sides having a first module guide channel located on one of the two module enclosure internal support sides and a second module guide channel located on the other of the two module enclosure internal support sides and at least one module, wherein the at least one module includes a module rear, a module front and module sides which define a module cavity, wherein each of the module sides include a side channel guide for interacting with the first and second module guide channels to support the module and wherein the at least one module may include a chimney module having a substantially vacant module cavity, wherein if a chimney module is included it may be associated with the at least one fan to direct air flowing out of the fan through the chimney module cavity toward the at least one vent opening.

A modular power control system is provided and includes a base enclosure, a base enclosure door, wherein the base enclosure and base enclosure door define a cavity for containing electrical components, wherein the base enclosure door includes a plurality of base connectors which are in electrical communication with the electrical components such that each base connector is connected to a plurality of electrical power phases; a module enclosure having a module enclosure top, a module enclosure bottom and two module enclosure sides which include module guide channels, wherein the module enclose defines a module enclosure cavity and includes a fan on the module enclosure bottom and a vent opening in the module enclosure top and a module, wherein the module includes a module rear, a module front and module sides which defines a module cavity having a module electrical component, wherein each of the module sides include a side channel guide for slidingly interacting with the module guide channels to support the module within the module enclosure cavity and wherein the module rear includes a module power connector configured to mate with the base connector when the module is contained within the module cavity such that the module electrical component is connected to at least one of the plurality of electrical power phases.

A modular power control system is provided and includes a base enclosure and a base enclosure door, wherein the base enclosure and base enclosure door define a cavity for containing electrical components, wherein the base enclosure door includes a plurality of base connectors which are in electrical communication with the electrical components such that each base connector is connected to a plurality of electrical power phases. The modular power control system also includes a module enclosure having a module enclosure top, a module enclosure bottom and two module enclosure sides which include module guide channels and a module, wherein the module includes a module rear, a module front and module sides which defines a module cavity having a module electrical component, wherein each of the module sides include a side channel guide for slidingly interacting with the module guide channels to support the module within the module enclosure cavity and wherein the module rear includes a module power connector configured to mate with the base connector when the module is contained within the module cavity such that the module electrical component is in electrical communication with at least one of the plurality of electrical power phases

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features and advantages of the present invention will be better understood from the following detailed description of illustrative embodiments, taken in conjunction with the accompanying drawings in which:

FIG. **1** is a top down perspective exploded view of a Modular Power Control System (MPCS), in accordance with one embodiment of the present invention.

FIG. **2**A is front isometric view of the base enclosure of the MPCS of FIG. **1**.

FIG. **2**B is front view of the base enclosure of the MPCS of FIG. **1**.

FIG. **3**A is a front perspective view of the base enclosure door of the MPCS of FIG. **1**.

FIG. **3**B is a rear view of the base enclosure door showing the base enclosure door cavity of the MPCS of FIG. **1**.

FIG. **4**A is a rear view of a power connector of the MPCS of FIG. **1** illustrating the pin configuration.

FIG. **4**B is a rear view of the first and second power connectors of the MPCS of FIG. **1** illustrating the pin configuration.

FIG. **4**C is a rear view of the third and fourth power connectors of the MPCS of FIG. **1** illustrating the pin configuration.

FIG. **4**D is a rear view of the fifth and sixth power connectors of the MPCS of FIG. **1** illustrating the pin configuration.

FIG. **4**E is a rear view of a power connector illustrating the pin configuration in accordance with an additional embodiment.

FIG. **5** is a front side isometric view of the module enclosure of the MPCS of FIG. **1**.

FIG. **6** is a front side isometric view of the module enclosure internal support of the MPCS of FIG. **1**.

FIG. **7**A is top side isometric view of one embodiment of a module for use with the MPCS of FIG. **1** illustrating an 'open' design.

FIG. **7**B is top side isometric view of multiple embodiments of modules for use with the MPCS of FIG. **1**.

FIG. **7**C is top side isometric view of a chimney airflow module for use with the MPCS of FIG. **1**.

FIG. **8** is top side isometric view of a dimmer module for use with the MPCS of FIG. **1** illustrating an 'open' design.

FIG. **9** is top side isometric view of a relay (single-pole/double-pole) module for use with the MPCS of FIG. **1** illustrating an 'open' design.

FIG. **10** is bottom up view of one embodiment of a module for use with the MPCS of FIG. **1** illustrating an 'open' design.

FIG. **11** is a top side isometric view of the module enclosure front panel of the MPCS of FIG. **1**.

FIG. **12** is block diagram illustrating one embodiment of the PCB Backplane configured for Ethernet capability for use with the MPCS of FIG. **1**.

FIG. **13** is block diagram illustrating another embodiment of the PCB Backplane configured for DMX capability for use with the MPCS of FIG. **1**.

FIG. **14** is block diagram illustrating still yet another embodiment of the PCB Backplane configured for DMX capability for use with the MPCS of FIG. **1**.

FIG. **15** is front view of the module enclosure of FIG. **1** illustrating airflow within the module enclosure cavity.

FIG. **16** is chart illustrating some embodiments of various sizes of the MPCS of FIG. **1**.

DETAILED DESCRIPTION OF THE INVENTION

It should be appreciated that although the modular power distribution system of the present invention is described herein in terms of a dimmer array system, the concept of the invention may be used for any situation that requires power to be distributed. It should also be appreciated that the present invention may be a portable or permanently installed unit configurable for operation with single and multiple phase applications of up to 200 A (and in some cases greater than 200 A), such as power distribution application for LEDs, moving lights, traditional dimming, etc.

Referring to FIG. **1**, a Modular Power Control System (MPCS) **100** is shown and includes a base enclosure **102**, a base enclosure door **104**, a module enclosure **106**, a module enclosure internal support **108** and a module enclosure front panel **110**.

Referring to FIG. **2**A and FIG. **2**B, the base enclosure **102** includes a base enclosure front **112**, a base enclosure back **114**, a base enclosure top **116**, a base enclosure bottom **118** and two base enclosure sides **120**, wherein the base enclosure front **112**, base enclosure back **114**, base enclosure top **116**, base enclosure bottom **118** and base enclosure sides **120** define a base enclosure cavity **122**. Additionally, the base enclosure front **112** includes a base enclosure opening **124** which allows access into the base enclosure cavity **122**. Referring to FIG. **3**A and FIG. **3**B, the base enclosure door **104** includes a base enclosure door front **126**, a base enclosure door back **128**, a base enclosure door top **130**, a base enclosure door bottom **132** and two base enclosure door sides **134**, wherein the base enclosure door front **126**, base enclosure door back **128**, base enclosure door top **130**, base enclosure door bottom **132** and base enclosure door sides **134** define a base enclosure door cavity **136**. Additionally, the base enclosure door back **128** includes a base enclosure door opening **138** which allows access into the base enclosure door cavity **136**. The base enclosure door also includes a plurality of power connector openings **140** and a plurality of signal connector openings **142**.

It should be appreciated that the base enclosure door **104** is attached to the base enclosure **102** via a hinge **144** such that the base enclosure door **104** is rotatable between an open configuration and a closed configuration. When in the open configuration, the base enclosure cavity **122** and base enclosure door cavity **136** are accessible. When in the closed configuration, the base enclosure door back **128** aligns with the base enclosure front **112** to enclose the base enclosure cavity **122**/base enclosure door cavity **136** and such that the base enclosure opening **124** and base enclosure door opening **138** are proximate each other. A base enclosure locking member may be included on at least one of the base enclosure **102** and the base enclosure door **104** to limit access to the base enclosure cavity **122** and the base enclosure door cavity **136**.

Referring again to FIG. **2**A and FIG. **2**B, the MPCS **100** also includes a power input opening **150**, a power supply **152**, a Phase A power input terminal **154**, a Phase B power input terminal **156**, a Phase C power input terminal **158**, a power output distribution block **160**, a ground terminal **162** and a neutral terminal **164**, wherein the power supply **152**, Phase A power input terminal **154**, Phase B power input terminal **156**, Phase C power input terminal **158**, power output distribution block **160**, ground terminal **162** and neutral terminal **164** are securely located within the base enclosure cavity **122**. Additionally, referring again to FIG. **3**A and FIG. **3**B, the MPCS **100** also includes a plurality of power connectors **166**, a plurality of signal connectors **168** and PCB Backplane **170** which are located within the base enclosure door cavity **136**. The plurality of power connectors **166** are associated with the plurality of power connector openings **140** and the plurality of signal connectors **168** are associated with the plurality of signal connector openings **142** such that the interface portion

of the plurality of power connectors **166** and signal connectors **168** are accessible via the base enclosure door front **126**. It should be appreciated that the number of power connectors **166** and signal connectors **168** may be dependent on the number of modules that the MPCS **100** can accommodate. Additionally, referring to FIG. **4**A each of the power connectors **166** include a first power input port **172**, a first power output port **174**, a second power input port **176** and a second power output port **178**.

It should be appreciated that the three-phase power is introduced into the MPCS **100** via the power input opening **150** and includes a Phase A conductor that is connected to the Phase A power input terminal **154**, a Phase B conductor that is connected to the Phase B power input terminal **156** and a Phase C conductor that is connected to the Phase C power input terminal **158**. The three-phase power also includes a neutral conductor that is connected to the neutral terminal **164** and a ground conductor that is connected to the ground terminal **162**. Additionally, the power supply **152** may be powered via the three-phase power by connecting the power input of the power supply **152** to at least one of the Phase A power input terminal **154**, Phase B power input terminal **156** or Phase C power input terminal **158**.

Referring to FIG. **4**B, FIG. **4**C and FIG. **4**D, one embodiment of the connection of the power phases to the plurality of power connectors **166** is illustrated. As shown, the MPCS **100** is configured to accommodate six (6) modules and thus includes a first power connector **180**, a second power connector **182**, a third power connector **184**, a fourth power connector **186**, a fifth power connector **188** and a sixth power connector **190**. The first power connector **180** is configured to have a Phase A power input and output and a Phase B power input and output, the second power connector **182** is configured to have a Phase C power input and output and a Phase A power input and output, the third power connector **184** is configured to have a Phase B power input and output and a Phase C power input and output, the fourth power connector **186** is configured to have a Phase A power input and output and a Phase B power input and output, the fifth power connector **188** is configured to have a Phase C power input and output and a Phase A power input and output and the sixth power connector is configured to have a Phase B power input and output and a Phase C power input and output. It should be appreciated that the phase power inputs of the plurality of connectors **166** are connected to the appropriate Phase power input terminal and the and the phase power outputs of the plurality of connectors **166** are connected to the power output distribution block **160** for distribution to external loads. The signal connectors **168** are connected to the PCB Backplane **170**. Moreover, power conductors from the power supply **152** are also connected to the PCB Backplane **170** to provide power to the PCB Backplane **170**.

It should be appreciated that various types of power connectors **166** may be used in response for different configurations. For example, the power connectors **166** may vary from a four (4) pin configuration (See FIG. **4**A) and may include a six (6) (or more) pin connector **167** (See FIG. **4**E). In this embodiment, the six (6) pin connector **167** includes pins for two phases, where each phase includes a power phase output pin, a power phase input pin and a neutral pin. Other connector configurations are also contemplated and are responsive to the application.

Referring to FIG. **5**, the module enclosure **106** includes a module enclosure front **192**, a module enclosure rear **194**, a module enclosure top **196**, a module enclosure bottom **198** and two module enclosure sides **200**, wherein the module enclosure rear **194**, module enclosure top **196**, module enclosure bottom **198** and module enclosure sides **200** define a module enclosure cavity **202**. Additionally, the module enclosure rear **194** includes a module enclosure rear opening **204** and the module enclosure front **192** includes a module enclosure front opening **206** to allow access to the module enclosure cavity **202** from both the module enclosure front **192** and the module enclosure rear **194**. Referring to FIG. **6**, the module enclosure internal support **108** includes a module enclosure internal support rear **208** and two module enclosure internal support sides **210**, where the module enclosure internal support rear **208** includes an internal support opening **212**. The module enclosure internal support **108** is securely located within the module enclosure cavity **202** such that the internal support opening **212** is aligned with the module enclosure rear opening **204**. It should be appreciated that the module enclosure internal support **108** is securely attached to the module enclosure rear **194** and/or the module enclosure sides **200** via screws. The module enclosure internal support **108** further includes a plurality of module guide channel pairs **214**, where one of the channels of the module guide channel pair **214** is located on one side of the module enclosure internal support sides **210** and the other of the channel of the module guide channel pair **214** is located on the other side of the module enclosure internal support sides **210**. These module guide channel pairs **168** are configured to slidingly receive and contain a module **216** within the module enclosure **106**, where one channel of the module guide channel pairs **214** include a resilient member **218** which interacts with the module **216** as discussed further hereinafter to lockingly and securely contain the module **216** within the module guide channel pair **214**.

Referring to FIG. **7**A and FIG. **7**B, one embodiment of the module **216** is shown and includes a module housing **220** having a module housing front **222**, a module housing rear **224** and module housing sides **226**, wherein the module housing front **222**, module housing rear **224** and module housing sides **226** define a module housing cavity **228** for containing module components. It should be appreciated that the module components are dependent upon the function of the module **216**. For example, in one embodiment referring to FIG. **8** if the module **216** is a dimmer module, then the module **216** may contain dimmer power components (such as two (2) or more SCR 120V 10 A dimmers) as well as dimmer control circuitry. In another embodiment, referring to FIG. **9** if the module **216** is a relay module, then the module **216** may contain single-pole (such as two (2) Single-Pole 20 A 120V relays) or double-pole (such as one (1) Double-Pole 20 A 220V relay) relays as well as relay control circuitry/switches. It is contemplated that the modular power control system (MPCS) **100** may include any mix of different type modules **216**. For example, although the MPCS **100** is described herein as using relay and dimmer modules, any type of modules that may be used for power distribution applications (i.e. for architectural, entertainment, etc.) may be used, such as modules that provide power and control of fluorescent ballasts and various other dimming techniques. Also, the modules may be used for power distribution and control to various other types of electronic/electrical equipment. It should be appreciated that the present invention advantageously provides access to all power phases as desired without having to reconfigure the entire system.

Additionally, referring to FIG. **7**C, it should be appreciated that module **216** may be configured as a chimney airflow module **217**, where the module housing cavity **228** is left unpopulated and substantially free of obstruction. The configuration of the chimney airflow module **217** advantageously acts as a flow path guide to direct airflow between the module

enclosure bottom **198** and the module enclosure top **196**. This is discussed in further detail hereinafter.

Furthermore, the module housing cavity **228** may be divided into a front cavity portion **230** and a rear cavity portion **232**. The module housing sides **226** include a side channel guide **234** that is configured (i.e. size and shape) to slidingly and supportingly interact with the module guide channel pair **214**, where the side channel guide **234** on one module housing side **226** fits into one of the channels of the module guide channel pair **214** and the side channel guide **234** on the other module housing side **226** fits into the other of the channels of the module guide channel pair **214**. It should be appreciated that one (or more) of the side channel guides **234** are sized such that when the side channel guides **234** are contained within the module guide channel pair **214**, the resilient member **218** prevents the module **216** from being removed from the module guide channel pair **214**. When the resilient member **218** is compressed, the module **216** may be removed from the module guide channel pair **214**.

Moreover, referring to FIG. **10**, the module housing rear **224** includes a module housing power connector **226** for providing input and output phase power to and from the module **216** and a module housing signal connector **228** for providing control signals to and from the module **216**. The module housing power connector **226** is configured to mate with a power connector of the plurality of power connectors **166** and the module housing signal connector **228** is configured to mate with a signal connector of the plurality of signal connectors **168**. As discussed further hereinafter, in one embodiment there is a power connector **166** and a signal connector **168** for each of the modules **216** and the power connector **166** and signal connector **168** are located on the base enclosure door front **126**, such that when the module **216** is located within the module enclosure **106**, the power connector **166** is mated to and connected with the module housing power connector **226** and the signal connector **168** is mated to and connected with the module housing signal connector **228**.

It should be appreciated one advantage of the present invention involves the physical distribution of the phases (Phase A, Phase B, Phase C) to the power connectors **166** (See FIG. **4**A-FIG. **4**D) which advantageously allows availability of and access to multiple phases for applications (via the module **216**) that use single or multiple phases (for example, single-pole or double-pole devices). Accordingly, while the invention is discussed herein as being used with dimmers and relays, a module of any functionality that incorporates single-pole or double-pole devices can be used with the present invention.

Referring to FIG. **11**, the module enclosure front panel **110** is shown and includes a module enclosure front panel front **236**, a module enclosure front panel rear **238** and a module enclosure front panel opening **240**. The module enclosure front panel **110** is configured to securely associate with the module enclosure front **192** such that when modules **216** are located within the module enclosure **106** (i.e. within the module guide channel pairs **214**) the module housing front **222** is accessible to allow circuit breaker switches to be turned on and off.

It should be appreciated that the PCB Backplane **170** may be a modular PCB that includes circuitry to connect the Modules **216** together and to supply power and to provide DMX/RDM and external control trigger capabilities. Referring to FIG. **12**, one embodiment of the PCB Backplane **170** which is configured for use with network capability (sACN and ArtNET) is shown. Referring to FIG. **13**, another embodiment of the PCB Backplane **170** which is configured for use with DMX/RDM ("daisy chain") capability is shown. Referring to FIG. **14**, still yet another embodiment of the PCB Backplane **170** which is configured for use with DMX/RDM and External Trigger Arrangement capability is shown. Additionally, other PCB Backplanes may be used that are configured for use with sACN and ArtNET protocols.

Accordingly, the present invention allows for multiple levels of control. For example, in one configuration control may be accomplished using Streaming ACN or ArtNet and provides a full range of feedback and control abilities, such as providing amperage, temperature and lamp hours and the ability to check the status of any channel in any module in any panel in the system. In another configuration control may be provided using DMX or RDM and may provide the ability to check the status of any channel 'downstream' of the plug-in point. Additionally, all of the modules/devices used in the MPCS **100** may be UL924-compliant devices.

In accordance with one embodiment of the present invention, the MPCS **100** (which may a self support structure or may be mounted to a structure) may be assembled as follows. The base enclosure **102** is obtained and the power supply **152**, Power Phase input terminals **154**, **156**, **158**, power output distribution block **160**, neutral terminal **164** and ground terminal **162** are secured within the base enclosure cavity **122**. This may be accomplished via any method suitable to the desired end purpose such as screws, adhesive, clips, etc. Three-phase power conductors are introduced into the base enclosure cavity **122** via an opening (not shown) where the Phase A conductor is connected to the Phase A input terminal **154**, the Phase B conductor is connected to the Phase B input terminal **156** and the Phase C conductor is connected to the Phase C input terminal **158**. Additionally, the neutral conductor of the input power is connected to the neutral terminal **164** and the ground conductor of the input power is connected to the ground terminal **162**. The power supply may be powered by the input power by connecting the power lead of the power supply to one of the Phase input terminals **154**, **156**, **158**. Additionally, the base enclosure door **104** is obtained and the plurality of power connectors **166** (where the number of power connectors **166** being used is dependent upon the number of modules the system can accommodate) are secured to the base enclosure door **104** such that the mating portion of the power connectors are protruding through the plurality of power connector openings **140** such that the mating portion of the power connectors are accessible via the base enclosure door front **126**. The PCB Backplane **170** is connected to the base enclosure door **104** to be located within the base enclosure door cavity **136** such that the plurality of signal connectors **168** are protruding from the plurality of signal connector openings **142**.

The base enclosure door **104** is connected to the base enclosure **102** (such that the base enclosure opening **124** is proximate to the base enclosure door opening **138**) via a hinge **144** which allows the base enclosure door **104** to rotate between a closed configuration (where the base enclosure door **104** covers and encloses the base enclosure cavity **122**) and an open configuration (where the base enclosure door **104** is rotated away from the base enclosure **102**). A locking device (not shown) may be provided to secure and/or lock the base enclosure door **104** in the closed configuration to limit and/or prevent access to the base enclosure cavity **122** for safety and/or security purposes. It should be appreciated that the locking device may be any type of locking device suitable to the desired end purpose, such as a lock/catch combination or the locking device may simply be one or more screws that secure the base enclosure door **104** to the base enclosure **102**. The power phases at each of the Phase input terminals **154**,

156, 158 are then connected to the power input pins of the power connectors 166 to be configured as shown in FIG. 4B, FIG. 4C and FIG. 4D and the output pins of the power connectors 166 are connected to the power output distribution block 160. Moreover, the power from the power supply 152 is connected to the PCB Backplane 170. The base enclosure door 104 is then configured into the closed configuration to enclose and isolate the base enclosure cavity 122 and the base enclosure door cavity 136 from the external environment. This configuration advantageously secures the base enclosure cavity 122 and the base enclosure door cavity 136 from unwanted access but also provides a high degree of safety by preventing unintended contact with high power components.

The module enclosure 106 is securely mounted to the base enclosure door 104 such that that the module enclosure rear opening 204 is adjacent the base enclosure door front 126. Guide pins may be provided on the on the base enclosure door front 126 and guide holes may be provided on the module enclosure rear 194 to help position the module enclosure 106 for mounting. It should be appreciated that the module enclosure rear opening 204 allows access to the plurality of power connectors 166 and plurality of signal connectors 168 via the module enclosure front opening 206. The module enclosure internal support 108 is located within the module enclosure cavity 202 and mounted to the module enclosure sides 200 and/or module enclosure rear 194. The module enclosure 106 may be secured to the base enclosure door 104 and the module enclosure internal support 108 may be secured to the module enclosure 106 via any device or method suitable to the desired end purpose, such as screws, clips, adhesive, etc. It should be appreciated that the design of the module enclosure 106 and module enclosure internal support 108 allow for the module enclosure cavity 202 to be substantially open. It should be further appreciated that one or more airflow fans 242 (powered by the power supply 152) may be mounted (via screw, clip, adhesive, etc.) on the module enclosure bottom 198 under the modules 216 and vent openings 244 may be included on the module enclosure top 196. Additionally, it should be appreciated that the chimney airflow module 217 may be associated with the module enclosure internal support 108 to be located proximate the module enclosure bottom 198.

Referring to FIG. 15, this configuration advantageously creates and functions as a "heat chimney" within the module enclosure, with the chimney airflow module 217 directing the air flow from the airflow fans 242 upward toward the modules 216 and out of the vent openings 244. Additionally, the modules 216 are configured as an 'open' design (See FIG. 7A) where the top and bottom of the module 216 is open (or includes openings) to accommodate airflow through the module 216 to flow between the top of the module 216 and the bottom of the module 216. This advantageously allows the airflow to contact the components within the module 216 and thus any heat generated from the module component is directed up and out of the module enclosure 106 via the vent openings 244. It should be appreciated that the Modular Power Control System (MPCS) 100 may or may not include (one or more) chimney airflow modules 217 as desired. For example, in a Modular Power Control System (MPCS) 100 which is filled with modules 216 a chimney airflow module 217 may not be used. Moreover, in a Modular Power Control System (MPCS) 100 which is not completely filled with modules 216, the empty module locations may be kept empty as desired.

At this point, one or more modules 216 may be located within the module enclosure 106 by inserting the side channel guides 234 of the module 216 within the module guide channel pairs 214 and sliding the module 216 along the module guide channel 214 toward the back of the module enclosure cavity 202. As the module 216 approaches the back of the module enclosure cavity 202, the module housing power connector 226 and the module housing signal connector 228 contact the power connector 166 and signal connector 168, respectively and mate together such that the power and signal leads from the module housing power connector 226 is connected to the power connector 166 and such that the module housing signal connector 228 is connected to the signal connector 168. This advantageously provides power and signal connection between the module 216 and the base enclosure 102.

Accordingly, when the airflow fans 242 are activated, the air flow path is directed upward toward the vent openings 244. As discussed above the chimney airflow module 217 may be used to further direct the airflow to the modules 216. This advantageously creates and operates as a "heat chimney" directing the airflow over the module component and directing heat from the modules components up and out of the vent openings 244.

In accordance with one embodiment of the present invention, a method for reducing heat within a module enclosure is provided and includes creating and/or receiving an airflow into the enclosure, directing the airflow through the enclosure such that the airflow is at least partially incident on at least one of the heat generating and/or non-heat generating components and directing the airflow out of the enclosure, where the airflow may be created/directed using active methods (i.e. fans) and/or passive methods (guides).

It should be appreciated that the enclosure proportions may be based on airflow and/or Ampacity requirements. This advantageously allows for the enclosures to be reduced in size. For example, FIG. 16 shows one embodiment of different sizes for an MPCS 100 relative to Ampacity with varying number of modules. Additionally, the configuration of the present invention advantageously provides a degree of isolation between the internal components of the MPCS 100 and the external environment, resulting in a safer system and reducing/eliminating the introduction of dust and other debris into the MPCS 100. Furthermore, the fan(s) 242 may be operated on a continuous basis (no on/off noise transitioning) to advantageously allow the MPCS 100 to be used in noise sensitive environments. Moreover, the communication ability of the modules may allow the modules 216 to have the ability to report operational characteristics. For example, the module may be configured to report the temperature and amperage present at each channel. Or the module may be configured to check amperage, temperature or lamp hours of any other module from anywhere in the system. Also, modules may have zero-cross sensing to prevent arcing and extend the life of all the relays, whether they are single, double or dimming.

Additionally, it is contemplated that multiple MPCS's 100 may be connected together to create a larger control array. Furthermore, the design of the MPCS 100 allows modules with single-pole devices and modules with double-pole devices to be used in the same system. Also, the design allows modules to be stacked in numerical order (if desired) and do not require balancing.

It should be appreciated that although the MPCS 100 of the present invention is discussed herein as having six (6) modules, the MPCS 100 of the present invention is preferably configured to accommodate any number of modules (in multiples of three (3)) suitable to the desired end result, such as 3, 6, 9, 12 or 15 modules. This is because the power phases (Phase A, Phase B, Phase C) are distributed across three (3) of the power connectors 166. For example, as discussed herein-

above, the first power connector **180** provides a connection to power Phase A and power Phase B, the second power connector **182** provides a connection to power Phase C and power Phase A and the third power connector **184** provides a connection to power Phase B and power Phase C. Accordingly, this configuration advantageously helps to ensure that the loads connected to the power phases are as balanced as possible across all three (3) phases (Phase A, Phase B, Phase C). It should be appreciated that in the above configuration the power phase-connector pattern (A-B, C-A, B-C) may be repeated every third power connector **166**. However, it should be appreciated that although the modules are discussed herein as being in groups of three (3, 6, 9, 12, 15, 18, etc. . . .) for load balancing purposes, any number of modules may be used as desired, such as 4, 5, 7, etc. . . . . In this case, the system would operate, but would be unbalanced and thus less stable.

It should be appreciated that while the invention has been described with reference to an exemplary embodiment, it will be understood by those skilled in the art that various changes, omissions and/or additions may be made and equivalents may be substituted for elements thereof without departing from the spirit and scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims. Moreover, unless specifically stated any use of the terms first, second, etc. do not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another.

What is claimed is:

1. A modular power control system, comprising:

a base enclosure having a base enclosure top, a base enclosure bottom, a base enclosure front, a base enclosure rear and two base enclosure sides, wherein the base enclosure defines a base enclosure cavity;

a base enclosure door having a base enclosure door top, a base enclosure door bottom, a base enclosure door front, a base enclosure door rear and two base enclosure door sides, wherein the base enclosure door defines a base enclosure door cavity;

a module enclosure having a module enclosure top, a module enclosure bottom, a module enclosure rear and two module enclosure sides, wherein the module enclose defines a module enclosure cavity and includes at least one fan on the module enclosure bottom and at least one vent opening in the module enclosure top;

a module enclosure internal support, wherein the module enclosure internal support includes a module enclosure internal support rear and two module enclosure internal support sides having a first module guide channel located on one of the two module enclosure internal support sides and a second module guide channel located on the other of the two module enclosure internal support sides; and

at least one module, wherein the at least one module includes a module rear, a module front and module sides which define a module cavity, wherein each of the module sides include a side channel guide for interacting with the first and second module guide channels to support the module.

2. The modular power control system of claim **1**, wherein the at least one module includes a chimney module having a substantially vacant module cavity, the chimney module being associated with the at least one fan to direct air flowing out of the fan through the chimney module cavity toward the at least one vent opening.

3. The modular power control system of claim **1**, further comprising a base electrical component located within the base enclosure cavity, wherein the base enclosure door includes a plurality of base power connectors which are in electrical communication with the base electrical component such that each base connector is connected to a plurality of electrical power phases.

4. The modular power control system of claim **3**, wherein the module further includes a module electrical component located within the module cavity.

5. The modular power control system of claim **4**, wherein the module rear includes a module power connector electrically connected to the module electrical component and configured to mate with at least one of the base power connectors when the module is contained within the module cavity such that the module electrical component is connected to at least one of the plurality of electrical power phases.

6. The modular power control system of claim **3**, wherein the plurality of electrical power phases include Phase A power, Phase B power and Phase C power.

7. The modular power control system of claim **6**, wherein the plurality of base power connectors include a first base power connector connected to Phase A power and Phase B power, a second base power connector connected to Phase C power and Phase A power and a third base power connector connected to Phase B power and Phase C power.

8. The modular power control system of claim **1**, wherein at least one of,

the module enclosure internal support is contained within the module enclosure cavity and securely associated with and adjacent to the module enclosure rear and module enclosure sides, and

the base enclosure, base enclosure door, module enclosure and module enclosure internal support are constructed from a metallic material.

9. A modular power control system, comprising:

a base enclosure;

a base enclosure door, wherein the base enclosure and base enclosure door define a cavity for containing base electrical components, wherein the base enclosure door includes a plurality of base connectors which are in electrical communication with the base electrical components such that each base connector is connected to a plurality of electrical power phases;

a module enclosure having a module enclosure top, a module enclosure bottom and two module enclosure sides which include module guide channels, wherein the module enclose defines a module enclosure cavity and includes a fan on the module enclosure bottom and a vent opening in the module enclosure top; and

a module, wherein the module includes a module rear, a module front and module sides which defines a module cavity having a module electrical component, wherein each of the module sides include a side channel guide for slidingly interacting with the module guide channels to support the module within the module enclosure cavity and wherein the module rear includes a module power connector configured to mate with the base connector when the module is contained within the module cavity such that the module electrical component is connected to at least one of the plurality of electrical power phases.

10. The module power control system of claim **9**, further comprising a chimney module having a chimney module rear, a chimney module front and chimney module sides which

defines a substantially vacant module cavity, wherein when the chimney module is located within the module enclosure cavity the chimney module is located above the fan such that air flowing from the fan is directed through the chimney module cavity toward the vent opening.

11. The modular power control system of claim **9**, wherein the plurality of electrical power phases include Phase A power, Phase B power and Phase C power.

12. The modular power control system of claim **11**, wherein the plurality of base power connectors include a first base power connector connected to Phase A power and Phase B power, a second base power connector connected to Phase C power and Phase A power and a third base power connector connected to Phase B power and Phase C power.

13. The modular power control system of claim **9**, wherein side channel guides are configured to slidingly interact with the module guide channels to support the module.

14. The modular power control system of claim **9**, further comprising a module enclosure internal support, wherein the module enclosure internal support is contained within the module enclosure cavity and securely associated with and adjacent to the module enclosure rear and module enclosure sides.

15. The modular power control system of claim **9**, wherein the base enclosure, base enclosure door, module enclosure and module enclosure internal support are constructed from a metallic material.

16. A modular power control system, comprising:

a base enclosure;

a base enclosure door, wherein the base enclosure and base enclosure door define a cavity for containing base electrical components, wherein the base enclosure door includes a plurality of base connectors which are in electrical communication with the base electrical components such that each base connector is connected to a plurality of electrical power phases;

a module enclosure having a module enclosure top, a module enclosure bottom and two module enclosure sides which include module guide channels; and

a module, wherein the module includes a module rear, a module front and module sides which defines a module cavity having a module electrical component, wherein each of the module sides include a side channel guide for slidingly interacting with the module guide channels to support the module within the module enclosure cavity and wherein the module rear includes a module power connector configured to mate with the base connector when the module is contained within the module cavity such that the module electrical component is in electrical communication with at least one of the plurality of electrical power phases.

17. The modular power control system of claim **16**, wherein the plurality of electrical power phases include Phase A power, Phase B power and Phase C power.

18. The modular power control system of claim **17**, wherein the plurality of base power connectors include a first base power connector connected to Phase A power and Phase B power, a second base power connector connected to Phase C power and Phase A power and a third base power connector connected to Phase B power and Phase C power.

19. The modular power control system of claim **16**, further comprising a module enclosure internal support, wherein the module enclosure internal support is contained within the module enclosure cavity and securely associated with and adjacent to the module enclosure rear and module enclosure sides.

20. The modular power control system of claim **19**, wherein the base enclosure, base enclosure door, module enclosure and module enclosure internal support are constructed from a metallic material.

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